PRACTICAL
ENGINEER

VOL. XVI CHICAGO, MAY 15, 1912 No. 10

PLANT OF THE NORWICH STATE HOSPITAL

Central Plant for Furnishing Building of a Connecticut State Institute with Light, Heat, Power and Refrigeration. Building and Chimney of Concrete Construction, 3-Wire System of Electric Distribution and Tunnel for Piping Are Features of the Plant

BY CHARLES L. HUBBARD

THIS LAYOUT IS OF especial interest as illustrating the method of heating and lighting a group of public buildings from a central plant. A block plan of the various buildings of the institution is shown in Fig. 2, which includes those already erected or in process of erection. The plant is what might be termed a "progressive plant," having been started in 1904, at which time Ward A buildings were erected and a single boiler and generating set were temporarily installed in a barn nearby.

This apparatus was operated continuously for nearly 3 yr., when the new power house, shown in Fig. 1, was erected, together with 4 other buildings and their connecting corridors. The boiler and generating set were moved to their new quarters and the capacity of the plant increased by adding 3 more boilers and a second generating set, having twice the capacity of the first. Other extensions have been

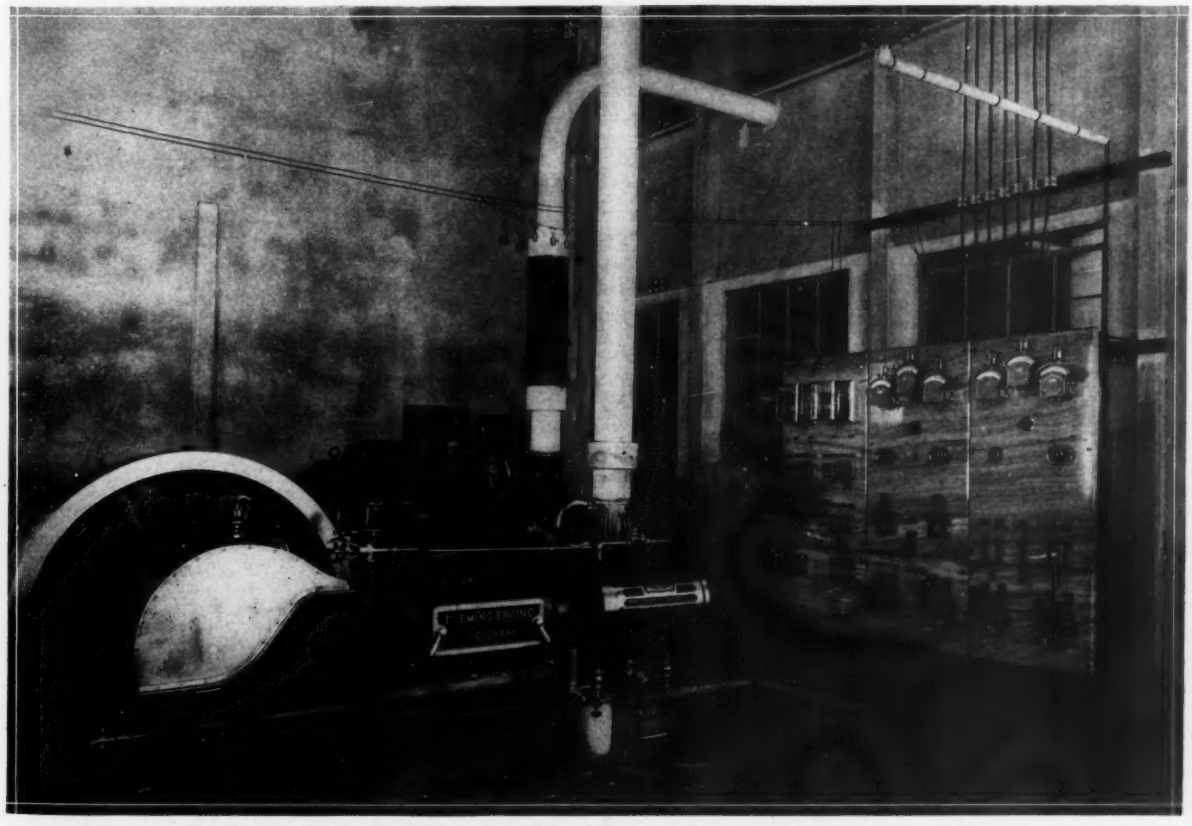


FIG. 4. GENERAL VIEW OF THE ENGINE ROOM IN THE HOSPITAL PLANT

made from time to time until the plant stands practically as shown in Figs. 2 and 3. The institution occupies a level plateau about 60 ft. above the Thames river which flows along the rear of the grounds.

The power house is directly back of the administration building at a grade some 50 ft. below that of the other buildings, this location being chosen in order to bring it on the line of the railroad which runs between it and the river.

Coal and freight are brought alongside by means of a spur track, as shown. Coal is unloaded directly from the cars into bins, and general freight and supplies are

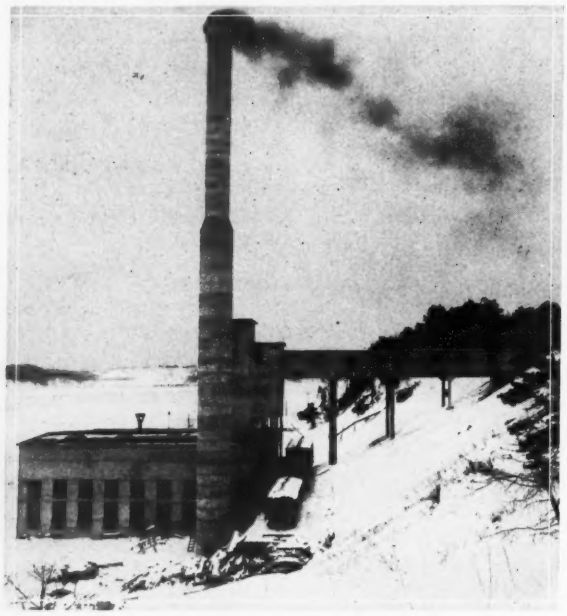


FIG. 1. EXTERIOR VIEW OF POWER PLANT

placed on trucks and raised by means of an elevator to the covered corridorway, which connects with all of the buildings.

Power House

THE power house, Fig. 1, is of re-enforced concrete construction, and contains a boiler room, engine room, pump room and space for refrigeration, as shown in the plan, Fig. 2. The chimney is of concrete, 150 ft. in height, with a circular flue 6 ft. in diameter. It is intended at a later date to install an economizer outside the building at the rear of the boilers, and the main smoke pipe is designed for adapting it to this purpose, as will be seen by an inspection of Fig. 2.

This pipe is constructed of heavy black iron upon an angle iron frame, and has a sectional area of 30 sq. ft., it is supported from the over head construction of the building and provided with a balanced damper at the point shown. Individual adjusting dampers are provided in the uptake from each boiler for equalizing the draft, these being regulated by hand, while the main damper is operated automatically by means of a hydraulic damper regulator.

It is proposed at a later date to construct a coal pocket of ample capacity at the rear of the building so located that the coal can be unloaded into it from the cars without rehandling. This will occupy a position directly below the cars shown in Fig. 1. The connecting corridors and pipe tunnels are of concrete construction, 8 ft. in width, by 8 ft. in height, which gives ample space for the running of pipes and cables and for the passage of trucks. It may be well to mention here that all buildings are of fireproof construction, so far as it is possible to make them so in an institution of this kind.

Boilers

THE boiler plant consists of 6 horizontal tubular boilers, each 72 in. in diameter, and containing 96 lap welded tubes, 3½ in. in diameter, by 18 ft. in length.

The shells are 7/16 in. in thickness, of open hearth fire box steel, having a guaranteed tensile strength between 55,000 and 62,000 lb. per square inch. The heads are ½ in. in thickness, of open hearth flange steel. The longitudinal seams are of the triple riveted butt-joint type with double covering strips, arranged to come well above the fire line. Girth seams are single riveted lap-joint pattern, with ⅞-in. rivet pitched 2½ in. on centers.

Bracing is of the crow-foot type, with 23 stays, 1⅛ in. in diameter, attached to each head by 2 ⅞-in. rivets; no braces being less than 3½ ft. in length. The manhole covers and frames are of cast steel, located in the shell on top. The nozzles are of similar material, 5 in. internal diameter. Each boiler is supported by 8 gun iron lugs, 4 on each side placed in 2 groups.

The smoke openings are 12 by 60 in. in size, with vertical uptakes as shown on boiler room plan. The internal feed pipe to each boiler is of brass, 1½ in. in diameter, and supported from the braces.

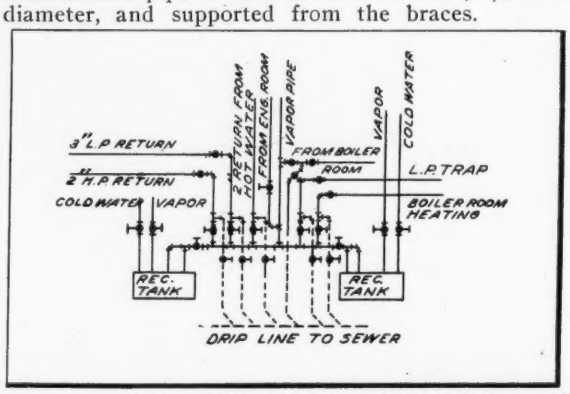


FIG. 5. GENERAL ARRANGEMENT OF DRIP CONNECTIONS

Each boiler has a 2-in. blowoff connecting with a 3-in. main which leads to a dry well outside the building.

Engines and Generators

THERE are 3 generating sets in use at the present time, located as shown in Fig. 2. A direct-current at 220 volts on a 3-wire system is used for lighting and operating the various motors. The smaller unit consists of 2 25-kw. generators driven by a 12 by 12-in. direct connected Harrisburg-Fleming single-valve, side crank engine. The larger units each consist of 2 50-kw. generators of the same type driven by a 16 by 14-in. engine of the same make. The engines operate under a boiler pressure of about 85 lb. per square inch, and during the heating season the exhaust is utilized for general heating purposes at a pressure not exceeding about 2 lb. under ordinary conditions. The engines operate normally at about ¼ cutoff, and are provided with centrifugal inertia governors so designed as to work equally well under a cutoff ranging from 0 to 75 per cent. One feature of particular interest is the self oiling system, by means of which

all important bearings are lubricated from a reservoir by the centrifugal action of the crank. A general view of the engine room is shown in Fig. 4.

Piping

IN Fig. 2 is shown the general arrangement of the heavy boiler room piping. The leads from the 6 boilers connect with a 10-in. loop so valved that any boiler may be cut out for repairs. This plan also permits of all the steam being delivered to the power or heating plant as may be desired, or they may both be supplied at the same time which is the usual condition during the heating season.

The engines are supplied from a special drum having an 8-in. valved connection with the 10 in. loop as shown. Direct steam separators are provided in the steam pipes to the engines as indicated in Fig. 4. All high-pressure piping, and the separators are dripped to the receiving tank through high-pressure traps. The general method of connecting with the 12-in. low-pressure heating main is indicated in dotted lines. Live steam is provided through a pressure reducing valve of Wateis make, these being furnished with cut-out and by-pass valves. Exhaust steam from the engines and pumps is admitted to the heating main beyond the reducing valve, after having first passed through an oil separator. Connections are also made for the use of exhaust steam in the heating of feed water and in supplying hot water for laundry and domestic purposes. The condensation from the main heating system flows back to the boiler house by gravity, where it is trapped into the receiving tank and pumped back to the boilers. There are duplicate outfits for this purpose, each consisting of a Williams trap and a Warren 7½ by 5 by 6-in. duplex pump and receiver, so connected that either may be used or both together as desired. The general method of making the connections of the various drips and returns with the receiving tanks is shown in Fig. 5. All piping throughout the buildings and tunnels is standard weight, the fittings on all high-pressure work are extra heavy, while standard weight are used elsewhere. Fittings of the screw pattern are used, with the exception of the 12-in. heating main and the boiler and engine room piping, where flanged fittings are employed. Valves with outside screw and yoke of Walworth make are used in connection with the heavy piping in the power house, for other work Chapman valves with inside screw are employed.

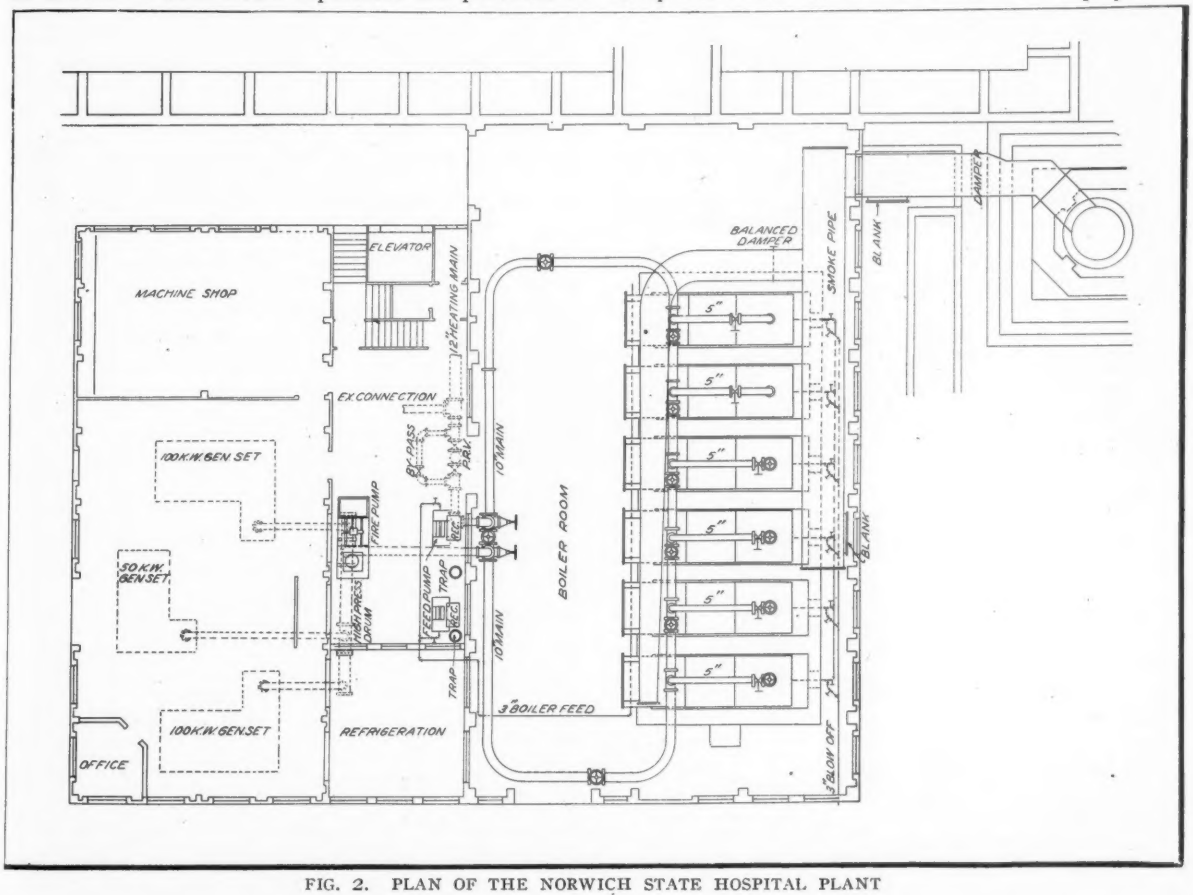


FIG. 2. PLAN OF THE NORWICH STATE HOSPITAL PLANT

H. W. Johns-Manville Asbestos Sponge pipe covering is used throughout the plant; heating pipes in buildings, and the returns having a thickness of 1 in., and all high-pressure work and the heating mains in the tunnels having a thickness of 1½ in.

The feed-water heater is of the I. B. Davis Company's make and located above the pump room, although not shown on plans.

Hot water for domestic purposes is furnished by a Gleaner heater placed in the power house and connected with the various buildings by means of a system of mains and branches. A second heater of the same type is provided in the laundry building.

An interesting feature in connection with the power plant is the use of the 12-in. heating main as a condenser in the summer time when the buildings are shut off. By opening the windows of the corridor

ways and allowing the air to circulate over the main, a considerable degree of vacuum can be obtained.

General Scheme of Heating

STEAM from the boiler house is supplied to the various buildings through a 12-in. main and 8-in. loop, aggregating some 3700 ft. in length and shown in Fig. 3.

FIG. 6. VIEW OF TUNNEL, SHOWING HEATING MAIN AND HIGH-PRESSURE LINE

Exhaust steam, supplemented by live steam introduced through a reducing valve, is circulated through the main at a low pressure, 1 lb. being found sufficient to fill the radiation at the extreme ends of the run. The condensation from the buildings on this line is carried back to the boiler house under a gravity flow where it is trapped into a vented receiver and pumped back to the boilers.

In addition to the heating main there is a high-pressure line for supplying steam for laundry and cooking purposes, food-warmers, vent-flue heaters, etc. Full boiler pressure of 80 lb. is carried to the laundry, and from here on it is reduced to 35 lb.

The heating system of the Superintendent's House is on the high-pressure line, a special reducing valve and trap being placed in the basement of the building A general view of the 12-in. heating main and the high-pressure line in the tunnel leading from the power house is shown in Fig. 6.

Fire Station or Hose House

A LARGE fire pump located in the power house connects with a system of hydrants placed at suitable points throughout the grounds. A building for housing the fire apparatus is located at the point shown. This is heated and lighted in a manner adapted to its purpose.

This work was designed by and installed under the direction of the Richard D. Kimball Co., engineers of New York and Boston.

INCREASE IN VOLUME of business handled has made it necessary for the Weber Chimney Co., of Chicago, to take larger quarters and the offices have been removed from 209 So. State St. to 1452 McCormick Building, Chicago.

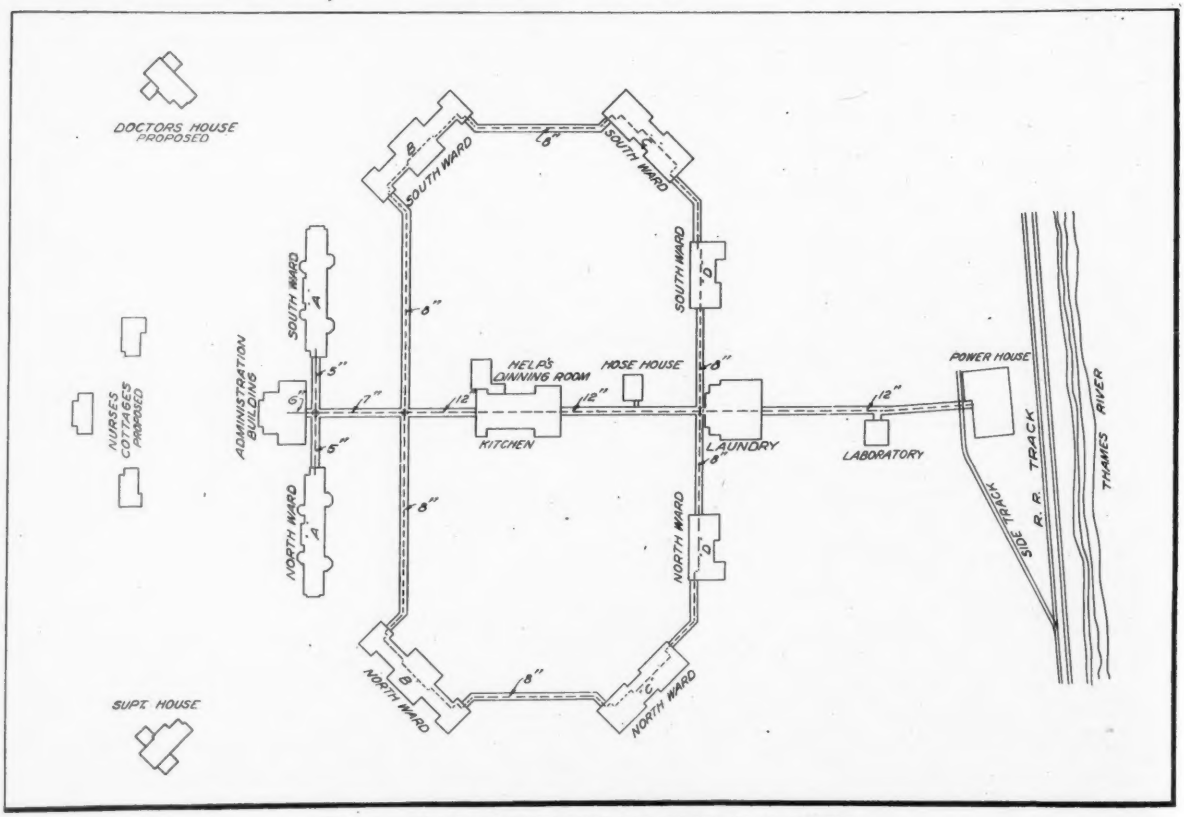


FIG. 3. PLAN OF BUILDINGS ON HOSPITAL GROUNDS

THE FEDERAL METALLIC PACKING CO., formerly located at 164 Canal Street, Boston, Mass., has removed to larger quarters at 48 Hanover Street.

DOES THE INDICATOR LIE?

Facts Disclosed by an Investigation of Indicator Diagrams and Possible Wrong Conclusions as to Valve Settings

By E. S. Libby

"WHAT IS THE CAUSE of the wavy expansion line on an indicator card?"

This question is asked many times by the operating engineer when taking cards from a steam engine and he is often at a loss as to its real cause.

In high speed work, say 300 r.p.m., there are many causes for this wavy expansion line, such as the drum spring being too weak, which does not permit the drum to rotate in unison with the motion of the piston, especially on the return stroke; or too much travel for the drum and too light a spring in the indicator. It is always well to have a small drum so that a short stroke of drum may be obtained without distortion due to inertia of the drum and the card should not be too high.

For low-speed engines there is less likelihood of obtaining the wavy line, unless there is water in the

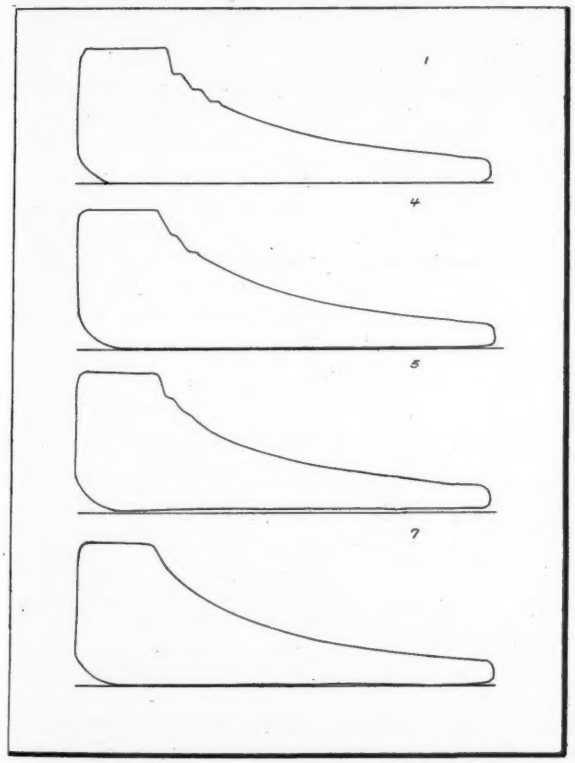


FIG. 2. CARDS WITH CROSBY INDICATOR, SHORT CONNECTION, STEEL PISTON, BRASS CYLINDER; 1 AND 4 DRY, 5 AND 7 OILED

connections or the piston is not free to respond to the pressure which acts on it.

The writer recently conducted a few experiments with different indicators to see whether there were any other conditions such as water in the cylinder, dirt in indicators, both dry and with pistons oiled, steel and brass pistons that would cause this wavy expansion line.

The Experiment

CARDS illustrated were taken from the head end of the high-pressure cylinder of a 9 and 18 by 24 cross-compound Corliss engine, located in the steam laboratory of the Armour Institute of Technology.

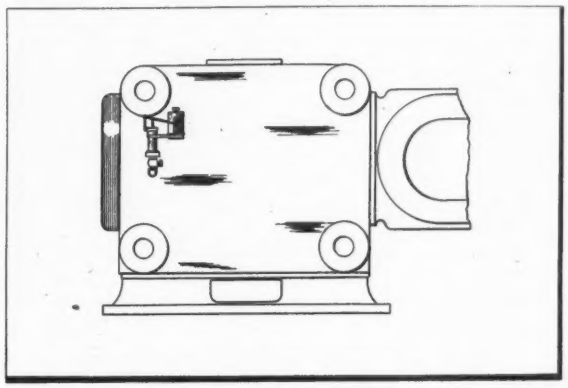


FIG. 1. SHORT INDICATOR CONNECTION TO CYLINDER

The speed of the engine was 94 r.p.m. No attempt was made to hold the load constant, so that the horsepower varied somewhat. Several indicators were used, so that the cause of the wavy line could not probably

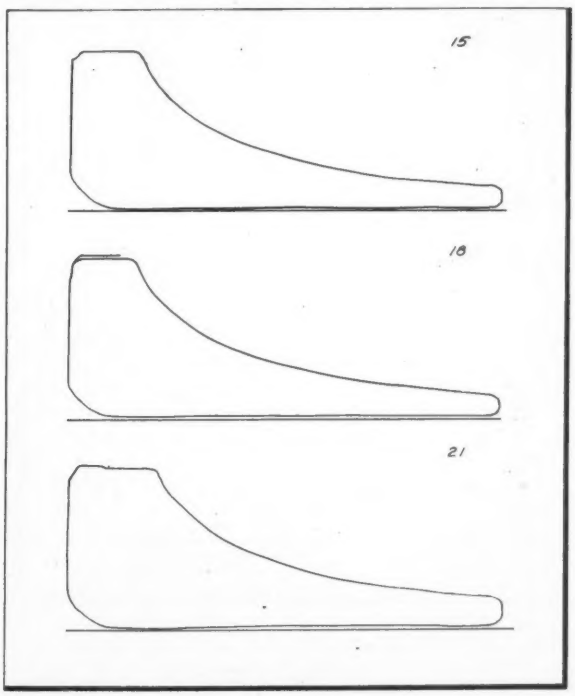


FIG. 3. CARDS WITH BRASS PISTON AND CYLINDER; 15, DRY; 18 AND 21, OILED

be in the indicator. The first part of the investigation was conducted with a short indicator connection as shown by Fig. 1, with different indicators both running dry and with pistons oiled.

Dry vs. Oiled Pistons

A CROSBY indicator with a steel piston and brass cylinder was first used with results as shown by cards Nos. 1, 4, 5 and 7. Cards Nos. 1 and 4 were taken with indicator thoroughly cleaned but without oil on the piston, while cards Nos. 5 and 7 were taken with the indicator piston oiled. Cards Nos. 1 and 5

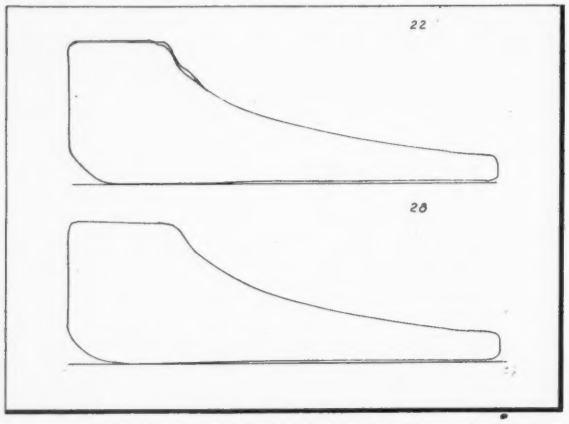


FIG. 4. DIAGRAMS FROM BRASS PISTON AND CYLINDER; 22, NOT OILED; 28, OILED

were taken after indicator had been in operation for one-half a minute. Card No. 5 shows a much better expansion line than card No. 1, while in card No. 7 the wavy expansion line practically disappears. This shows that oil on a steel piston, with dry steam, is

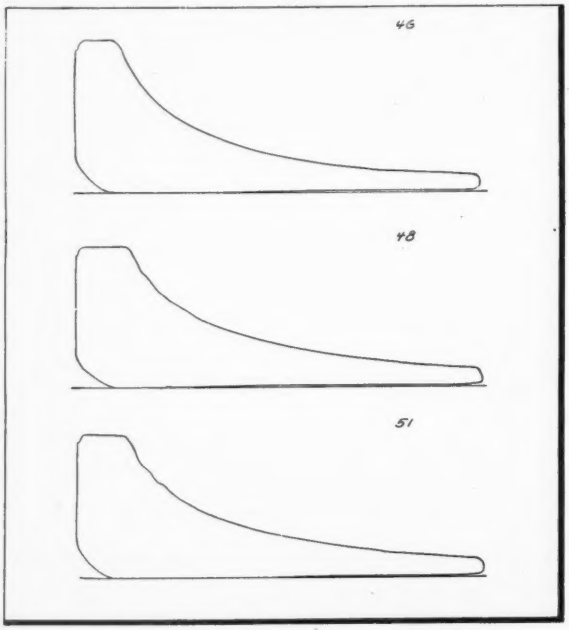


FIG. 5. CARDS USING TABOR INDICATOR, BRASS PISTON AND CYLINDER; 46, WITHOUT OIL; 48 AND 51, OILED

needed to prevent the piston from sticking and causing a wavy expansion line.

A Crosby indicator with a brass piston and cylinder was then used with the results as shown by cards Nos. 15, 18 and 21. Card No. 15 was taken with indicator clean but without oil while cards Nos. 18 and 21 were taken with piston oiled. Cards 15 and 18 were taken after indicator had been in operation but 3 revolutions, while card No. 21 shows results when indicator was allowed to operate for ½ min. The expansion line is

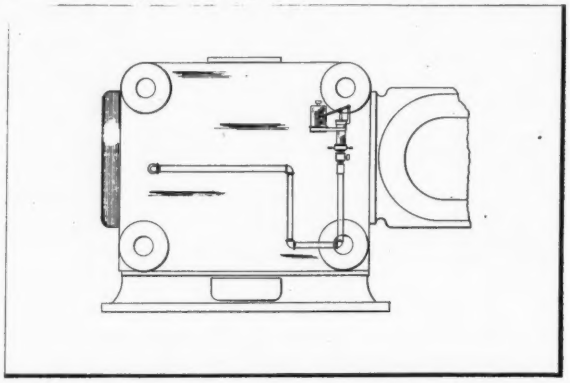


FIG. 6. LONG CONNECTION OF INDICATOR TO SECURE THE EFFECT OF VERY WET STEAM

practically a smooth curve under both conditions with this indicator, showing that with brass piston it would

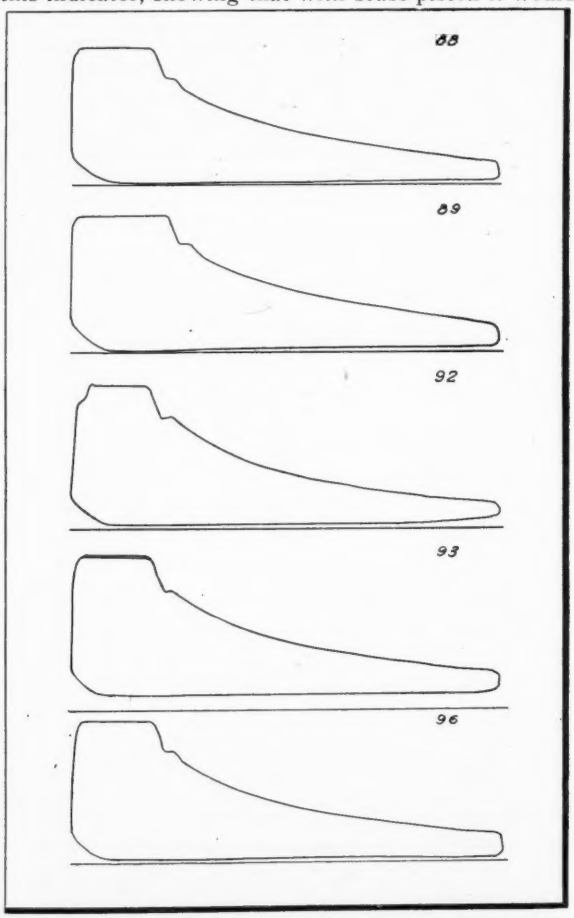


FIG. 9. CARDS FROM A SECOND CROSBY INDICATOR; 88, 89, DRY PISTON, DRY PIPE, 88 AFTER 3 REV., 89 AFTER ½ MIN.; 92, 93, OILED PISTON, WET PIPE, 92 AFTER 3 REV., 93 AFTER ½ MIN.; 96, OILED PISTON, DRY PIPE AFTER ½ MIN. RUNNING

make but little difference whether indicator was oiled or run dry.

The writer has found that in using an indicator

with a steel piston it requires more care in order to obtain a perfect representation of the pressure changes in the cylinder of an engine. Cards Nos. 22 and 28 were taken from another Crosby indicator with a brass piston. Card No. 22 was taken with piston not oiled while card No. 28 was taken with oiled piston. The results obtained with this indicator are practically the same as those shown by cards Nos. 15, 18 and 21.

A Tabor indicator with brass piston was then tried with results illustrated by cards Nos. 46, 48 and 51. Card No. 46 was obtained without oil, while Nos. 48 and 51 were obtained with oil on the piston. The expansion line is practically a smooth curve with or without oil, which checks with the results as shown by cards taken with the 2 Crosby indicators with brass pistons.

It must not be taken from the above that the writer advocates using indicators without oil, but on the contrary, 2 pieces of metal in contact with each other and one or both in motion, require lubrication to reduce friction.

Effect of Water

THE question of water, or rather very wet steam, in the cylinder was next taken up. To introduce water direct into the steam line to the engine would in all probability be disastrous to the engine, so the indicator connection was changed as shown by Fig. 6. Here the pipe was run to the crank end with a U in the pipe just below the indicator. This gives the effect of a long indicator connection as well as offering means of having condensation in the indicator connection, by the application of wet cloths on the piping, which would allow a mixture of water and steam to act on the piston of the indicator.

The Tabor indicator, as used above, was first used with results illustrated by cards 52 to 66. Wet cloths were placed on the piping from the head end and on one leg of the U, thus insuring water acting with the

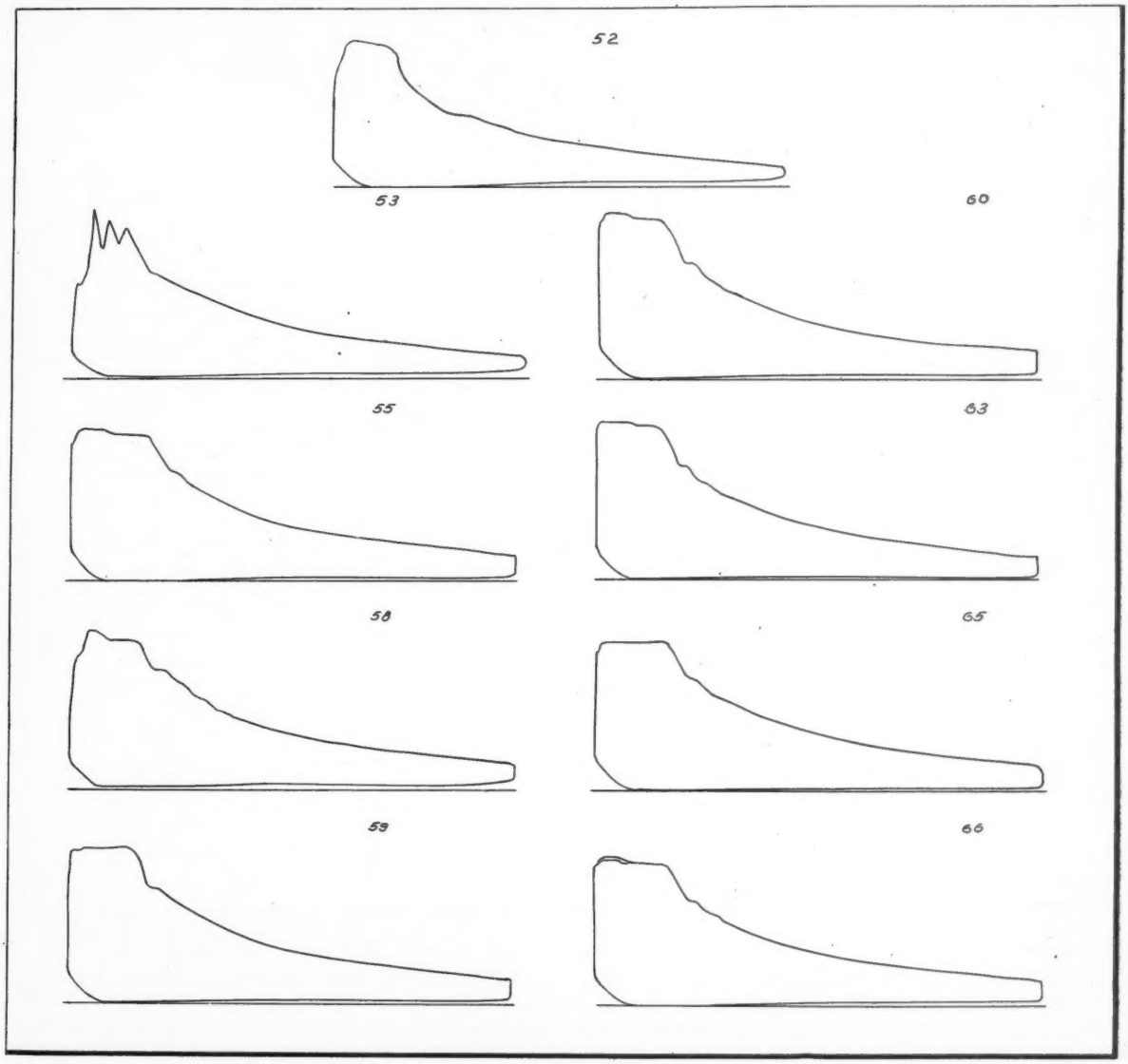


FIG. 7. CARDS FROM TABOR INDICATOR WITH LONG CONNECTION AND WET RAGS; 52, 53, 55, WITHOUT OIL ON PISTON; 58, 59, PISTON OILED; 60, 63, CLOTHS REMOVED, PISTON OILED; 65, 66, NO OIL

steam on the piston of indicator. Cards 52, 53 and 55 were taken without oil on the piston. Card 52 was taken after indicator had been in operation for 3 rev. The indicator was then allowed to operate for about ½ min., which is illustrated by card No. 55. By allowing the indicator to operate for some time the condensation is blown out and gives the effect of a long indicator connection. It is seen from the above that not only is the expansion line affected, but the admission, steam and exhaust lines as well, by the water acting with the steam on the piston of the indicator, evaporating to hold up pressure.

The indicator was then oiled, everything else remaining the same, and cards taken as before, with the results as shown by cards Nos. 58 and 59. Card 59 expansion, admission or steam lines, and holds up the back pressure line, which is shown more clearly by card No. 53. If no cloths are used, but simply the bare pipe, then the effect is that of a long indicator connection.

A Crosby indicator with brass piston was next used with the results as shown by cards Nos. 69 to 82.

Cards Nos. 69 and 70 were taken without oil on the piston and with wet cloths on the indicator pipe, while cards Nos. 73 and 74 were taken without cloths on piping. Cards Nos. 77 and 78 were taken after the indicator had been oiled and with wet cloths on piping. The cloths were then removed with the results as shown by cards Nos. 81 and 82.

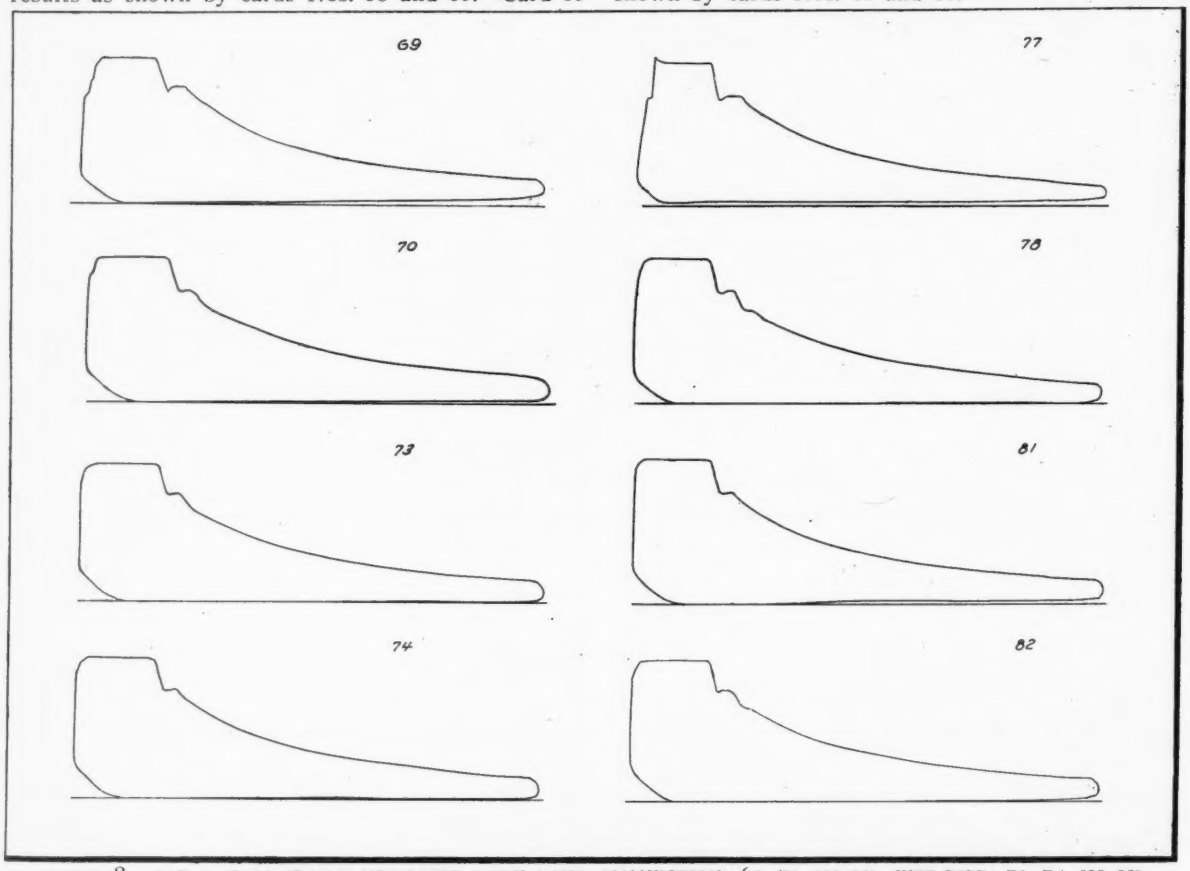


FIG. 8. CARDS FROM CROSBY INDICATOR WITH LONG CONNECTION; 69, 70, NO OIL, WET PIPE; 73, 74, NO OIL, DRY PIPE; 77, 78, OILED PISTON, WET PIPE; 81, 82, OILED PISTON, DRY PIPE

was taken after indicator had been in operation for about ½ min.

The wet cloths were removed and indicator oiled with the results as shown by cards Nos. 60 and 63, where card No. 60 was taken after indicator had been in operation but 3 rev., and card No. 63 had been in operation for ½ min.

The indicator was then cleaned and run without oil on the piston with results as shown by cards Nos. 65 and 66. Card No. 66 was taken after indicator had been in operation for one-half minute.

Summing up the results obtained with this indicator we see that it makes very little difference whether indicator is oiled or run dry, from which we may conclude that the water acts as a lubricant for the piston. Water in the indicator connection does not give smooth

Cards Nos. 69, 73, 77 and 81 were taken after indicator had been in operation but 3 rev., while cards Nos. 70, 74, 78 and 82 were taken after indicator had been in operation for ½ min.

The results obtained after indicator had been in operation for some time does not show so marked a wavy expansion line as when allowed to operate for only 3 rev.

These results in a general way conform with those shown by cards Nos. 52 and 56 taken under similar conditions.

Cards Nos. 83 to 96 were taken with a Crosby indicator with brass piston. The results obtained with this indicator are practically the same as obtained with the other Crosby indicator with brass piston.

The expansion lines obtained by using these 2 Crosby indicators is rather different from those ob-

tained with the other indicators; just after cutoff the expansion line drops, as if there were a leak or the exhaust valve were open at this point in the stroke and permitted the steam to blow through.

Cards were also taken with an indicator with steel piston under similar conditions as above with practically the same results.

Conclusions

THE conclusions drawn from the above results may be stated briefly thus: (1) It is always advisable to have the indicator clean and well oiled, especially with a short connection, or when a steel piston is used; (2) long connections will produce a slight wavy expansion line; (3) the wavy expansion line may be the fault of the indicator, due to workmanship; (4) water mingled with the steam in the indicator pipe and allowed to act on the piston of indicator, will cause not only a wavy expansion line, but will seriously affect the admission steam, and exhaust lines, giving false indications as to valve setting; (5) oiling does not seem to affect the results materially when water is present with the steam, the water acting as a lubricant.

THE FUEL COST OF MAKING STEAM

Guides in the Selection of Coal, Solution of Problems in Fuel Economy

By S. Milton Clark

COAL is purchased for power plants for the purpose of evaporating water. The coal bill is, in most cases, the largest item in the list of operating costs. An error in the choice of the kind of coal to use may cost many dollars and, on the other hand, a little observation may make a saving of many dollars. It is the purpose of this article to explain a simple and rational means of judging the value of coal, and to show how comparisons may be made.

Since coal is purchased to evaporate water, the coal which performs this operation at the least cost is the coal best fitted for the purpose. It is obvious at the outset that the same coal will not be the cheapest for all plants. One plant may have a small grate area and a poor draft, necessitating perhaps a higher grade of fuel than another plant having more grate area and a better draft. In any case it is necessary to know what evaporation is being obtained. For the benefit of those who are unfamiliar with the use of the word "evaporation," in its technical sense, it means the number of pounds of water changed into steam per pound of coal burned. In operation of plants it has been found most convenient to get this by measuring daily the coal fired and the boiler feed water.

By weighing coal as it is wheeled from bunker to fire room, and by taking meter readings of the feed water, the average evaporation for every 24 hr. may be kept on record. Such evaporation, however, does not show the maximum or even running evaporation that is being obtained, for the coal consumed in banking fires during periods of light loads or when boilers are shut down over night, is charged and reduces the average rate of evaporation. Still, the boiler plant is used solely for producing steam; hence, it is right that all coal consumed should be charged to such production. For a given plant, conditions of load from day to day are more or less similar, so there is no error in the comparison of daily evaporations by including the coal used for banking.

An alternative would be to make an allowance for the coal so used, but this would involve a complication subject to much error. For example, take the case of a plant in a manufacturing establishment that operates during the day and shuts down over night. The fires are banked at night and the steam pressure falls during the period of inactivity. In the morning the banked fires are brightened up and some coal is used, in addition to what was used for banking the previous night, for the purpose of getting up pressure.

All the coal used for banking at night and for getting up pressure in the morning is not directly used for evaporating water, but the coal fire just previous to shutting down at night is not completely consumed when the fire is banked. Also, in the morning, when getting up steam, the coal fired just previous to reaching the working pressure, when the engines are started, is not completely consumed at the time operation or the day's run of evaporation is commenced. Thus it will be evident that it is impossible to make a correct allowance for coal not directly used for evaporating. But, as has already been stated, the boiler plant is used solely for producing steam, hence it is right that all coal consumed should be charged to such production.

In plants where there is no feed water meter and where it is inconvenient to weigh coal continuously, several evaporative tests can be made on different kinds of coal. A comparison of results will be of use in a manner similar to the comparison of daily records for other plants. To compare the value of coals it has been found convenient to use, as the basis of comparison, the fuel cost of evaporating 1000 lb. of water. The selection of 1000 lb. is merely arbitrary. This basis takes account of the 2 important factors, namely, the cost of coal and what we get for it.

Diagram 1 printed in the Reference Tables shows the relation between evaporation and fuel cost of evaporating 1000 lb. of water. It was obtained as follows:

$$\text{Cost of 1 lb. of coal} = \frac{\text{Cost per ton}}{2000}$$

If our evaporation is E pounds of water per pound of coal, then the cost of evaporating one pound of water

$$= \frac{\text{Cost per ton}}{2000 \times E}$$

And the fuel cost of evaporating 1000 lb. of water $= \frac{\text{Cost per ton} \times 1000}{2000 \times E} = \frac{\text{Cost per ton}}{2 \times \text{Evaporation}}$

To be strictly accurate, a factor of evaporation should be applied to the evaporation as determined by the daily consumption of fuel and water, to obtain the equivalent evaporation from and at 212 deg. F. But in a given plant the steam pressure carried and the feed water temperature are both practically constant, hence the factor of evaporation is practically constant. Moreover, to apply the factor of evaporation, it would be necessary to compute the average steam pressure and the average feed water temperature each day. The variation would be found to be so slight that the increased accuracy of figures is not worth the task.

The odd values of cost per ton used in plotting

some of the curves were used to show the value of certain coals in current use in New York City.

Thus we have:

$2.40 Cost per ton of coke screenings.
$2.60 Cost per ton of No. 3 buckwheat.
$3.00 Cost per ton of No. 2 buckwheat.
$3.15 Cost per ton of No. 2 buckwheat.
$3.35 Cost per ton of No. 1 buckwheat.
$3.50 Cost per ton of No. 1 buckwheat.
$3.60 Cost per ton of a common grade of soft coal.
$2.863 Cost per ton of No. 3 buckheat and the $3.65 soft coal mixed 3 parts to 1.
$2.81 Cost per ton of No. 3 buckwheat and the $3.65 soft coal mixed 4 parts to 1.
$2.775 Cost per ton of No. 3 buckwheat and the $3.65 soft coal mixed 5 parts to 1.

Illustration I

IF conditions in a plant are such that we can get an evaporation of 8 with a 4 to 1 mixture of No. 3 buckwheat and soft coal costing $2.81 per ton, we see from the diagram that the fuel cost of evaporating 1000 lb. of water is 17.5 cents. In such a case, would it be wise to change to No. 1 buckwheat costing $3.50 per ton? On the diagram we see that it would be necessary to get an evaporation of about 10 with No. 1 buckwheat to operate for the same cost as the 4 to 1 mixture. If the evaporation can be made to exceed 10, then the change is advisable. If less than 10, the change would involve a loss. The proposition might be presented another way. We can raise the evaporation from 8 to 9 by changing from 4 to 1 mixture to No. 1 buckwheat. Would a change mean a saving or a loss? The answer is, obviously a loss; for the fuel cost of evaporating 1000 lb. of water with No. 1 buckwheat, when the evaporation is 9, is 19.5 cents, or an increase of 2 cents.

Illustration II

SUPPOSE, in another plant, No. 2 buckwheat at $3.15 per ton is being used and the evaporation obtained is 8½. The corresponding fuel cost of evaporating 1000 lb. of water is 18.5 cents. But it is found that No. 3 buckwheat, costing $2.60 per ton, can be successfully burned. This looks cheaper, but on trial the evaporation is found to be 6. The corresponding fuel cost of evaporating 1000 lb. of water is 21.7 cents. Thus, a loss would be the result of such a change.

In the first illustration it was found more economical to burn the cheapest fuel, while in the second illustration it was found more economical to burn a higher priced fuel. Such problems as these are of frequent occurrence in plant operation.

A valuable method of following the operation of a plant is to determine the daily evaporation, as has been discussed, and then from Diagram I, get the fuel cost of evaporating 1000 lb. of water. This value, of course, will be the average for the day. It will vary from day to day. The course of the variations should be sought. Thus, in an office building, the Sunday cost would naturally be expected to be greater than it is for week days, due to the plant operating at a light and less efficient load. A change in fuel will automatically show up for the better or worse. A rising cost of evaporation may be due to soot collecting in the boiler tubes and thus reducing the evaporation. A change of firemen may alter the cost one way or another. At any rate, the plant owner wants his money spent for coal to be spent as economically as possible. The foregoing means of checking the daily operation will show him where he is at.

The evaporations, usual for isolated plants vary from 6 to 9. The wide limits chosen in the diagram are to show such cases as the following: An expensive grade of bituminous coal costing $4.25 per ton, would have to evaporate 12 lb. of water per pound of coal to compete with a fuel costing $2.22 per ton and operating at an evaporation of about 6.3. The full cost of evaporating 1000 lb. of water in each case is 17.7 cents.

Now, let us investigate what this item, the fuel cost of evaporating 1000 lb. of water, means to us. Suppose by careful operation and study we reduce this item from 18 cents to 16 cents, what actual saving have we made? Take the case of a plant where daily records are available. How many dollars each day are saved by reducing the fuel cost of evaporation? If this cost of evaporating 1000 lb. of water is reduced one cent, there will be saved as many cents per day as there is evaporated thousands of pounds of water per day. That is:

Daily saving in cents for each cent's reduction in the fuel cost of evaporating 1000 lb. of water =

Daily pounds of water consumed ÷ 1000

Or:

Daily saving in dollars for the same reduction =

Daily pounds of water consumed ÷ 100,000

Diagram II is a set of lines based on this relation. Illustration: In a plant where the daily water consumption in the boilers is approximately regular, as in a hotel, and about 150,000 lb., a 3-cent reduction in the evaporation cost means a saving of $4.50 per day, or $135 per month.

It may be well to call attention to the fact that in trying out various kinds of coal, should artificial draft be used with some and not with others, an allowance should be made in favor of those coals not requiring the artificial draft. The method of checking the daily operation of plants as here discussed, has been tried with much success on a number of plants in New York. Many interesting facts are brought to light, and much valuable data accumulated.—The Isolated Plant.

A RECENT FIRE in the plant of the Brooklyn (N. Y.) Factory Power Co., Ltd., occurred during the night in the shavings chute located near one of the boilers. The chute was full of shavings and the fire was caused by back draft from the boiler. One automatic sprinkler over the chute poured its rain upon the blazing mass with such effect as to put out the fire before the shavings were half consumed. The automatic alarm brought the fire department, but there was nothing left for them to do. The damage was so insignificant that no claim was made for insurance.

A GREAT DEAL of trouble would be saved if turbine manufacturers adopted a uniform clause in regard to the guarantee. The Terry Steam Turbine Co. incorporates in its contracts specification of the "Normal operating conditions" on which guarantees are to be based, but the machine to be capable of pulling full load with a minimum stated steam pressure and to withstand a stated maximum pressure. One manufacturer investigated an installation when the turbine was reported not to pull its load at night, and it was found that the company's own charts indicated that the steam pressure instead of being in the neighborhood of 140 lb. per sq. in. had been allowed to drop to no more than 35 lb. per sq. in.

CONVEYING AND ELEVATING MACHINERY

Bucket Carriers for Use in the Power Plant, Their Economic Field for Handling Coal and Ash, Capacities, Power Required and Operation Costs

By Reginald Trautschold

SYSTEMS of conveying and elevating machinery so far discussed have all been applicable to power house operations on a large scale; that is, the apparatus is such as is used in large as well as in smaller power plants. There are many power houses, however, of comparatively small size in which a system of apparatus for handling both the coal and the ash on the same equipment can be economically installed even though the net cost of such operation would not prove economical in a larger plant. A system in point that can be used for such double service and is commonly and satisfactorily used in many power houses is that known as the bucket carrier.

Such an equipment consists primarily of a system of buckets attached to an endless chain—or to 2 endless chains—following a more or less rectangular path. That is, the carrier is used as an elevator to raise the coal to the level of the coal bunkers over which it is then run horizontally, as a conveyor, discharging its load on such stretch. On the return run the carrier descends from the level of the coal bunkers and runs under the boiler room floor, where it again takes a horizontal path, acting as a conveyor running in an opposite direction to that taken when passing over the coal bunkers, and collects the ash from the various ash-pits, then elevates and discharges to some storage bunker. The accompanying illustration represents such a system, one end of the coal bunkers being used as a storage place for the ash until such time as it may be finally removed from the power house. The bunker for the temporary storage of ash need not necessarily be at the same elevation as the coal bunkers, but may be located at any convenient point.

LINK-BELT OVERLAPPING PIVOTED BUCKET CARRIER AND CROSS CONVEYORS DISTRIBUTING COAL INTO 5-TON POCKETS

Type of Buckets

BUCKETS of a bucket carrier are attached to the chains by connections that permit the buckets to retain their upright position in any plane, one manner of attaching the pivoted buckets being clearly shown in the illustration of the drive of the conveyor at the point where the plane of advancement changes. The necessarily numerous pin connections of the chains and attachments of the buckets are all subject to continual wear, which constitutes a drawback that limits the use of such carriers to comparatively small power houses, for the failure of any link or connection completely cripples both the coal handling and ash handling operations of the system, necessitating falling back on manual operation or pressing into service such other equipment as is obtainable about the plant.

In a small power house coal can be rushed to the boiler room in wheel-barrows or cars and the ash carried away in pails with only the attendant annoyance of the extra labor, but in a large plant a breakdown of the conveying machinery and a stoppage of the supply of coal in the necessary quantities—quantities in excess of the wheel-barrow—means drop in power, stop work, darkness or failure of whatever depends upon the power generated at the plant.

Bucket carriers may have buckets of almost any conceivable shape and their construction may vary considerably, but for power house work the buckets are usually rectangular in shape and are carried, on the horizontal stretches, by wheels running on rails or other track. Devices for tipping the buckets to discharge load also vary, but their general principle is the same. All these conditions affect the question of

power required for the proper operation of the apparatus under any conditions, but as it is impossible to consider all kinds of bucket carriers in this paper therefore the following discussion will be limited to the ordinary bucket carrier, such as is employed in the average comparatively small power house for handling coal and ash.

Capacity

THE fact that the buckets of a bucket carrier are usually attached to the chains, so that they follow each other in comparatively close succession when traveling along a horizontal path, subjects the carrying capacity of a system of such apparatus to 2 conditions; 1st, the size of the buckets; 2nd, the speed at which the conveyor is run. The first of these conditions, size of bucket, has been so standardized by practice that the capacity of any specific size of conveyor, designated in terms of the size of the bucket as length times width, may be considered as constant; the capacity varying directly with the size of the conveyor, i. e., size of bucket.

Condition of speed of conveyor is also pretty well standardized and is comparatively low in order to keep the constant wear on the pins and connections at a practical minimum. Ordinarily this speed is about 70 ft. a minute for conveyors destined to handle both coal and ash. It is true that fine coal can be carried at a higher rate of speed than can be most economically used for ashes, but it is seldom that the most efficient speed of conveyor, either for handling coal or for handling ash, is employed when the conveyor is designed to handle both these materials. The speed usually chosen, about 70 ft. a minute, is a mean between the most economic speed for handling each material, and is maintained constant irrespective of the nature of the load carried.

The capacity of various common sizes of bucket carriers, when run at a speed of 70 ft. a minute, is given in Table I, given in the Practical Reference Tables. Such capacities are based on the assumption that coal is to be handled. Conveyors handling ash have an hourly capacity of about ⅔ those given in the table, but as the quantity of ash to be handled in any power house is but 15 or 20 per cent in volume of the amount of coal burned to produce them, a conveyor large enough to care for the coal requirements will be much larger than is really required for handling the ash.

Power

POWER required to operate a bucket carrier consists of the sum of that necessary for the system when acting as an elevator, that required on the horizontal stretches to convey the load and that required to run the apparatus alone on the horizontal stretches, including the power consumed by unloading devices, etc. The power required to elevate the load is little more than the theoretical amount necessary for such work, as the buckets are not dragged through a receiving boot as in the case of an ordinary bucket elevator.

The power required to carry the load along the horizontal stretches is not constant throughout the upper and lower runs, the load seldom, if ever, being carried the full distance of either or ever carried over the 2 runs at the same time. For these reasons it is customary to figure the power required on only one run as constant and in this way care is taken of the maximum requirment in the consumption of power on all level reaches of the conveyor. This arbitrary division has proved a safe one in practice and it is well, on this account, to adopt it.

Power consumed by the apparatus is practically limited to that required for horizontal stretches of the conveyor, as theoretically the descending buckets should counterbalance any work required to raise them on the forward path. A reliable formula giving the horsepower required for any bucket carrier system may therefore be derived in which the variable factors are those of maximum load to be handled per hour, the distance through which the load is to be elevated (height of conveyor) and the horizontal travel of the buckets in one direction only. Such an equation is given in a convenient form as follows:

$$Hp.=(0.7638WL+1.5WH)\div 1000.$$

Where:—

Hp.=Horsepower required to operate the system.
W=Capacity in tons per hour.
L=Horizontal travel of buckets in one direction in feet.
H=Height to which load is elevated in feet—height of conveyor.

Initial Cost

BUCKET carrier systems may be more or less expensive but the cost of the average good and economic system for a power house varies closely with its capacity in handling coal and, as only the average installation can be considered in this paper, costs will be limited to those for equipment as ordinarily found in power houses using bucket carriers for handling coal and ash. The cost of such a system depends upon 4 distinct conditions: 1st., size of the buckets or capacity of the system; 2nd., the total length of the carrier, the sum of the vertical sections and the 2 horizontal stretches; 3rd., the total horizontal length of the conveyor and 4., upon the size of the carrier as it is upon this last point that the cost of the driving machinery, etc., parts common to all carriers, depends. These conditions all bear a certain relation to the size or capacity of the system and may therefore be most conventiently expressed in the form of an equation in which the variable factors are those of capacity, expressed in terms of tons per hour, and height and length of carrier. Such an equation is given below which is sufficiently accurate for forming a conservative estimate of the initial cost of a bucket carrier system for a power house.

$$C=0.578W(H+L)+0.0219WL+4.11W.$$

Where:—

C=Cost of apparatus in dollars.
W=Capacity in tons per hour.
L=Horizontal travel of buckets in one direction in feet.
H=Height to which load is elevated in feet, height of carrier.

Operating Cost

THE 3 charges to net operating cost of a bucket carrier system—cost of operation, cost of maintenance, and the burden of interest, taxes, insurance—vary considerably in their respective economy. The cost of operation, depending upon the power required and the cost of labor for attendance, together with the supplies necessary to keep the equipment in good running order, is comparatively low, as the power required is a minimum for the work accomplished, and the attendance, etc., that is necessary but small owing to the simplicity of the apparatus.

Cost of maintenance, on the other hand, is comparatively high on account of the numerous wearing

parts and the liability of a more or less serious breakdown at any time, not that such breakdown can not be guarded against by careful inspections of machinery at frequent intervals, and the necessity of minor repairs and renewals that must be made continually in order to forstall more serious difficulties. The burden of interest, etc., being figured on a comparatively low initial cost, if such cost is considered as an outlay covering equipment for performing several operations on 2 distinct materials rather than as the outlay necessary for machinery to handle coal or that for handling ash, adds but little to the net cost of operation.

Individual charges constituting the net operating cost may all be expressed as proportions of the system's capacity as a coal handler depending upon the height to which load is to be elevated, height of carrier, the horizontal distance over which load is to be carried, or both; for, though the ash handling capacity of such a system is less than the coal capacity of the same equipment, the cost of maintenance when handling ash is greater than when carrying coal. An arbitrary classification of equipment in terms of coal capacity per hour serves as a basis of initial cost per unit length of carrier and also serves as a base for power required per unit of elevation and horizontal travel. Furthermore, maintenance expenses based on such classification are about corrected in the case of ash by the excess charged to the cost of operation. Records derived from such classification are given in Table II in the Practical Reference Tables in terms of the cost of power per hour and also on the assumption that a horsepower per hour costs 2c—which agree closely with results attainable in the average power house where the conveying equipment is in frequent use and the economic value of the installation aimed at.

Various modifications of bucket carriers are frequently installed in power houses either for both coal and ash handling or for handling coal only. In the latter case the return run of the buckets follows the same general path as the carrying run. Some slight saving in initial expense for equipment is saved by such practice but, unless the system is to be kept at constant work carrying coal to the storage bunkers, the slight additional cost necessary to carry the return run of the conveyor under the boiler room floor and thus provide a means of handling the ash from the grates is advisable.

AIDS IN ENGINE TROUBLES

IF the engine fires irregularly, it may be due to any of the following causes: Insulation broken on wires, causing a short circuit in the electric current. The contact at the timer may be poor, or the terminals on the coil may be loose or corroded. The spark plug may be cracked, or the points not properly adjusted. They should be about 3/32 in. apart. In case of a weak battery they may be closed a trifle. The fuel supply may not be regulated correctly; it might be so rich it will not ignite, or so weak it cannot be ignited, in either case the engine would run irregularly. The spark coil may be poorly adjusted, or the platinum points pitted and stick.

Sometimes an engine will fire regularly but have no power. In this case it may be due to poor compression, which is due to worn or broken rings, broken or warped valves, leaky gaskets, scored or worn cylinder walls and weak valve springs. The fuel mixture may be weak, or lubrication poor. Muffler may be stopped with a sooty deposit until the back pressure will destroy the power. The exhaust valve may be lifted only part way, not allowing the burned charge to be expelled from the cylinder.

A hissing sound can be caused by a broken spark plug allowing the compression to be forced through the fracture, or by the compression blowing past the rings. A cracked exhaust pipe, or an open compression cock, will emit a hissing sound, as will a blown gasket between the exhaust pipe and the muffler.

In case the engine refuses to start, something may be broken, but, if such is not the case, the trouble will likely be found in some of the following: Cylinders dry for the want of oil; foul or broken spark plug; poor compression as described in irregular firing; the batteries may be exhausted or some of the connections broken; the switch may be broken, or not turned on. Water in cylinder caused by a leak in the water jacket will prevent the engine from starting. The inlet valve if not mechanically operated will many times stick and prevent the engine taking a charge of fuel. An excessive amount of lubrication in the cylinder makes starting difficult, especially in cold weather.

If engine runs well and stops suddenly, it may be caused by the spark plug being broken or blown out, a broken wire, or the batteries run down. A loose terminal may be the cause, tremble spring on spark coil stuck, trouble at contact points of timing device, gears jammed or broken, valves stuck or broken.

In case the engine runs but seems to have no power, look for the following: Over rich mixture, caused by too much gas and not enough air; weak mixture, caused by too much air and not enough gasoline; loose or slipping flywheel, insufficient lubrication, valves in bad condition, worn or broken rings, weak batteries.

If the engine has been running well and gradually slows up, missing explosions, look for trouble in the fuel supply, or fouled spark plugs, insufficient lubrication, weak batteries, wiring defective being nearly broken and hanging by a thread, or loss of compression.

Explosions in the muffler are due to any of the following: Exhaust valve stuck, weak mixture failing to burn in the cylinder and burning in the muffler, weak spark not firing the charge until the working stroke is nearly finished. In this case it will not burn while passing to the muffler.

The water getting too hot, causing overheating, is generally caused by some of the following: Clogged pipes, incorrect timing of the valve, fan not working, pump broken or disconnected, oil in the water, muffler stopped up and a very late spark. In case there are explosions in the mixing valve, look to the intake valve or its spring. The valve may be broken or leaking, or the spring may be weak, not seating the valve properly, or the mixture may be weak, late spark, or the valves incorrectly timed.

When the engine begins to knock it should be stopped at once and some of the following examined: Flywheel may be loose on the shaft, or the cylinder may be loose, rings may be broken or badly worn, bearings may be loose and need tightening, carbon deposit on the cylinder head, spark occurring too early, over-rich mixture, loose cross-head bearing, and defective lubrication—this will cause knocking when the piston is about to seize.—Gas Power.

THE WHEELER CONDENSER & ENG. CO. announce that Nathan Owitz has been appointed manager of their Cincinnati office, handling a line of high grade condensing machinery, consisting of surface and jet condensers, centrifugal pumps, air pumps, cooling towers, etc. Mr. Owitz has been in the sales department in the home office of the company for the past 6 yr. and is fully acquainted with the various lines of condensing apparatus.

THE USE OF COMPRESSED AIR IN BOILER SHOPS

Selection of Type of Compressor, Pressure Used, Installation and Care of Pipe Lines and Hose, Pneumatic Tools

By Thomas Aldcorn

IN these days of close competition, a boiler shop without air tools for one purpose or another is almost unthinkable. At the same time, there are many small and some large shops where extensions or improvements could be made, and the purpose of the present paper is to run over, briefly, the production, transmission, and use of air and air tools in a manner which, it is hoped, will be of interest, and helpful to some at least.

The character and quantity of output must of necessity influence or govern the machinery equipment of any shop. Now, from this standpoint, let us run over briefly any general boiler shop. Is the output standardized, and the work, mainly duplication in smaller or larger quantities? Is it special, each case almost individual, or does it fall in the much larger class of jobbing—that is part repair, and part manufacturing?

Each class may be further subdivided, but in final analyses, certain fundamental features will be found common to all, with a wide range of special methods, apparatus, and uses applicable to each class.

It should be borne in mind also that a discussion of the general subject will depend upon whether it is to cover an existing plant or the planning of a new installation.

A logical treatment, however, is to employ the natural subdivisions of production, or the methods and machinery of producing and storing compressed air, transmission or the piping and means for conveying air to the points of application, separators or devices for cleaning and drying the air and the final application or use of air through the medium of the standard tools and a large number of special appliances.

Conditions change as a shop develops and an equipment which in the beginning was adequate, and no doubt well selected to meet the then existing conditions, becomes inefficient and unsuited, due to gradual extension and additions not contemplated in the beginning. Besides the wide range of uses to which compressed air lends itself are not at first fully appreciated, and experience may call for the installation of a device or machine at a remote place, or the use of a special appliance calling for a considerable volume of air, any one of which causes will disturb the balance of a once perfect plant.

Best Working Pressure

GENERAL experience shows that for best all around work, the proper pressure at the point of application is from 90 to 100 lb., and in some cases even slightly higher, however, "100 lb. at the tool" will meet every requirement of 99 cases out of every 100.

To give 90 to 100 lb. at the task will call for a terminal or receiver pressure of from 100 to 110 lb., depending on the piping or transmission system to be discussed later. We now have the first production factor, pressure. Next comes the question of volume of air required and this in turn necessitates a careful study of present and future requirements. What types of tool, the number of each to be operated; the probable number operating at the same time, the average time of operation of each; what special appliances will be installed, is air to be reheated and what provision is to be made for growth?

Fairly accurate tables are obtainable, giving the air requirements for all standard tools and machines, and data is available from which the total volume of air needed can be readily worked out, or the manufacturer of compressor and tools will be very glad to assist in determining this second factor.

Type of Compressor

HAVING obtained the volume necessary, the third prime consideration is the power available for operating the compressor. Here again special conditions must govern, and it is not possible to lay down any hard and fast rule. If steam is at hand, a steam driven compressor of simple, duplex or compound type, depending on the steam pressure and volume of air, generally recommends itself. With low steam pressure from 75 to 100 lb. and a required volume not exceeding 800 cu. ft., a single air cylinder finds frequent use. This type is not the most economical from the steam standpoint, but is compact, simple in construction and has many desirable features.

Above 800 ft. and with the same low steam pressures, the duplex type with the advantage of 4 power impulses for each revolution is frequently employed. Either duplex or 2-stage air cylinders are used with this type. When the steam pressure is above 100 lb. compound cylinders should generally be employed, and especially if the steam pressure is much above 100 lb.

For the larger sizes, from 1000 cu. ft. up, compound steam cylinders are almost essential and also 2 stage air cylinders.

Larger units of 2000 cu. ft. and upwards should be of the Corliss type, their greater first cost being soon offset by the considerable saving effected by their low steam consumption.

It is also well when the volume of air to be supplied is large to install 2 units either having a capacity equal to light working demands or both together having a combined capacity equal to maximum demand and also some reserve for growth.

It is always well to figure on a machine or equipment in excess of immediate demands and then operate the plant at less than full speed with a resulting reserve capacity and increased life. In many shops where shafting is running near the location selected for the compressor, and surplus power is available, a belt driven machine forms the most satisfactory type. This should be arranged with tight and loose pulley, if small, or a clutch so that the compressor can be shut down, should occasion arise, without interrupting the operation of the entire plant. For belt driven, except in the smaller sizes, the duplex, that is 2 cylinders side by side, driven from 1 shaft having a pulley at the center, is the most desirable form, as it gives 4 compressions per revolution thus producing a more even belt load.

All belt driven machines of whatever size or type should be securely anchored to a foundation to insure correct alignment, and proper resistance to belt pull. In every instance where electricity is available, a belt compressor can be driven from a suitable motor. This arrangement is advantageous, in that it permits starting or stopping at will, without the intervention of

idle pulleys, clutches, or other power absorbing devices.

Motor Driven Compressors

LATELY electric motor driven compressors are in considerable demand. For the smaller sizes the motor is geared to the compressor and an automatic starting controller and pressure regulator can be furnished if desired. This will maintain practically a constant pressure, shutting down the motor when the desired limit is reached, or starting up when the pressure falls, due to an increased demand for air.

Still another method of driving in larger units is to mount the motor armature or rotor directly on the compressor shaft. This arrangement is without doubt, the most simple and efficient type of power driven compressor. It is, however, not available except in size from 500 cu. ft. and above, because mechanical and electrical reasons will not permit the manufacture of slow speed motors at sufficiently low cost to compare with motors for belt or gear drive. At the same time, the simplicity of this type and its high operating economy recommends its use wherever possible, even at a much higher first cost.

Compressor Piping

IN piping up the compressor, it is well if possible to take the inlet air from the shady side of the building, or from outside the engine room, where cool air can be obtained, as each 5 deg. F. reduction in initial temperature will effect a saving of 1 per cent in the operation of the compressor or intake air 25 degrees colder will increase the capacity of the compressor 5 per cent. It is also well to make the inlet of good size, and as short and direct as possible, to reduce inlet friction to a minimum.

Often, and always if in a dusty or sooty location, it is advisable to put a strainer on the exposed end of the inlet pipe or box. Such a strainer can be made readily by covering one side of a substantial box with wire netting, and putting outside of this, 1 or 2 layers of muslin, through which the air must be drawn. While a strainer is not essential under ordinary conditions, in many cases it is, and in nearly all cases strained air will help avoid lubrication troubles, and add to the life of valves, piston and glands.

Compressed air leaves the compressor at a fairly high temperature, averaging about 350 deg. F. As the amount of invisible moisture which can be held in air depends on its temperature, it is evident that all the moisture taken into the compressor is also discharged therefrom, to condense in the receiver, or air mains later on. That this needs consideration is evident when it is recalled that a 500-cu. ft. compressor will draw in through the intake pipe 300,000 cu. ft. of air per day of 10 hr., and on a damp rainy day, this may contain as much as a barrel of water for the day, although the average would be less.

Aftercooling

FOR this reason, especially in the larger installations, an efficient aftercooler is most desirable, and actually essential, if the transmission lines are long or exposed to the outdoors. An aftercooler is a device arranged to take advantage of the principle mentioned, i. e., air will carry a varying amount of moisture, depending on its temperature or at a given temperature air will hold only a certain amount of moisture beyond which it becomes saturated and the excess moisture will be precipitated as dew or rain. Hence if we can reduce the temperature of the air below that at which it will enter the transmission mains, moisture troubles will be very largely eliminated.

Of course, it must be remembered that when the air is actually used or expanded in the exhaust of the pump, engine, drill or other air driven device the rapid expansion causes a temperature reduction considerably below what can be obtained in the usual water cooled aftercooler, and there may be some precipitation from the compressed air at the point of application. Usually, however, the moisture noticed around air tools is on the outside and is really the accumulation from the surrounding air, like the moisture on the outside of a glass of ice water.

Use of the Receiver

FROM the compressor, the air passes to the receiver, which performs a twofold function: first, as an equalizer of the pressure to receive the rapid pulsations of the compressor's discharge, and like a spring, or the gas bag on a gas engine, equalizes or smooths out the pulsations, thus insuring a steady flow of air to the transmission lines; second, to contain a stored supply of compressed air, which helps the compressor over any sudden momentary increased demand for air.

There is, however, an erroneous idea current with regard to the storage of air, for without the use of an excessively large receiver, it is not possible to store more than a few seconds' or a minute's supply. It is therefore evident that except under peculiar conditions the storage feature should be ignored, and a compressor installed of sufficient capacity easily to take care of immediate and reasonable future requirements.

If possible, the receiver should always be set outside in a shady and cool place where the heated air from the compressor may have a chance to cool off, and precipitate as much moisture as possible. To take care of this, a suitable drain should be provided, and used frequently to blow off any accumulated moisture, or excess oil.

Frequently it is a good plan to install additional receivers at junction points, or elsewhere in the transmission system, to equalize the pressure, and to take care of any sudden or excessive local demand. These auxiliary receivers also act as separators to remove from the air, additional grit and moisture.

Piping Systems

TRANSMISSION systems or pipes conveying the air from the compressor to the various points of usage should receive most careful attention, both in location and in putting up. Lines should be made of ample proportion, and figured with due regard to equivalent areas. They should be run as direct as possible with few turns or angles, and it will pay in the end if bends or long turn fittings are used. Branches and outlets should be near enough to permit of sufficient tools being operated without the use of long hose lines, usually so that a 50-ft. hose will overreach another 50-ft. hose.

Each branch should have a tee and 2 outlets closed with good solid globe or gate valves. The practice of using nothing less than 1-in. pipe for branches is to be recommended. Full weight pipes, substantial fittings, first grade valves, and care in supporting mains, drops, and branches, are all essential, for it must be remembered that with air at 100 lb. pressure, a $^1/_{16}$-in. hole will leak the equivalent of a horsepower for each 5 min. Two or three such leaks even in a large plant would be a serious loss.

All piping should be carefully inspected, rapped to break loose inside scale and then blown out. All joints

should be made up with lead and screwed up tight, and every precaution taken to make the work permanently air tight. At suitable points, drip tanks or separators should be inserted in the mains, these being provided with drip cocks. Drip cocks should also be placed at all low points. Further, it should be the duty of some one to see that all drips are blown off frequently, and properly.

Outlets should all be provided with an approved form of universal quick acting and locking hose coupling, and the same form should be used through and on all hose for interchangeability.

Only the best grades of hose should be used, wire wound for the longer or leader hose, and a short length of plain tubing for connecting with the leader. All hose should be cared for. It is expensive and deteriorates rapidly, and it has been shown that many troubles charged against the tool have been due entirely to the use of poor grades of hose, which stripped or scaled inside, and clogged the valves or working part of the air tool equipment. The hose should be regarded as part of the tool equipment, and each man to whom hose is issued should be held responsible for its return in good condition.

In small shops, and in most cases for erection and field work, a portable self-contained type of compressor is desirable, and in such cases a gasoline engine driven compressor, or kerosene oil engine driven type of compressor meets the conditions admirably, inasmuch as these types do not require boiler or electric current, and they may be mounted on skids, and easily set up in some convenient place. This type of compressor being entirely self-contained and very light, for a given capacity, is a most admirable type of machine for this class of work, and has been developed to a point where it is thoroughly reliable, and can be operated by inexperienced help.

In every case when getting ready, the valve at the outlet should be opened an instant before connecting the hose. The hose should then be blown out, and then only the hose connected to the tool.

Air Using Tools

WE now come to the actual uses of compressed air. Aside from the line of standard power driven machine tools for the boiler shop, such as shears, bending rolls, punches, there are a large number of standard and special air tools fully as important, devised to meet peculiar conditions existing in each case. Limited space necessitates merely mentioning the names of most of these, and only a short review of the most important of these can be given.

The chipping, calking, and bending hammer in 6 or 8 different sizes is for every character and weight of work, from the thinnest to the heaviest plates. These tools range in weight from 6 to 16 lb., with strokes from 1 to 5 in. and these striking at from 840 to 3200 per minute, with air at 100 lb. pressure, acting on a $^1/_{16}$-in. diameter piston.

The varying sizes of pneumatic chipping tools makes it possible to select a hammer to meet any peculiar set of conditions, and the spring throttle, which is always under the control of the operator, permits an instantaneous adjustment of the blow, from a very light tap to the full power of the hammer, thus enabling intricate chipping to be done quickly.

The pneumatic riveting hammer of the long stroke type weighs from 14 to 21 lb., depending on the class of work for which intended and has from 620 to 1080 blows per minute. It is not safe to heat a steel rivet beyond a certain point if its fibrous texture is to be retained and the full strength of the rivet made available. If done by a machine which strikes rapid and powerful blows, the rivet fills the hole and is headed before it is cooled to any great extent, and as it cools and is followed up by the riveter, the plates are clamped tightly together. A riveting hammer consists simply of the barrel, valve box and valve, handle and trigger.

Along with pneumatic hammers come of course penumatic holders-on for backing up the rivets; jam riveters for working in restricted places or in flues and other positions where the ordinary riveter cannot be operated; rippers for cutting up tanks, boilers and other plate work; rivet busters for flogging off the heads of rivets and stay bolts, for purposes of repair or absolute dismantling of boilers and tanks; and other special devices of kindred sort, many of which are specially made, having been developed in some particular shop.

Pneumatic drills are made in sizes ranging from the smallest Midget type weighing 6 or 7 lb. to the powerful compound gear type having a capacity to drill up to 3 or 4 in. in metal and weighing up to 118 lb. In principle they consist of a multiple cylinder air-actuated engine, driving a crank shaft which is geared to the drill spindle or socket which takes the drill. On the smaller sizes the spindle speed is as high as 2,600 r.p.m., whereas in the larger compound types mentioned the spindle speed is as low as 36 r.p.m. The power of these drills varies of course with the air pressure, but it is astonishing to see how rapidly they work and what enormous power they have.

Scaling tools for removing the scale from the inside of boilers are nothing more than small light pneumatic tools striking a fairly light blow, but having a high speed, and they can accomplish an enormous amount of work in a most satisfactory manner in a very short time.

Pneumatic jacks in principle consist of a cylinder with a piston, and heavy piston rod projecting through the top head of the cylinder, the air being admitted to the bottom, the piston moves upward exactly as in the case of a hydraulic jack. These can be obtained in sizes from 1 ton to 20 tons.

Pneumatic forges for rivet heating or tool tempering are light and compact, hence readily transferrable and can be taken close up to where the work is being done, thus insuring hot rivets without burning.

Pneumatic grinders of several sorts can be obtained and these are desirable for finishing edges of plates, corners or for any other special grinding where it is desirable to take the tool to the work. They consist of a standard form of air motor, practically the same as that used in the pneumatic drills, with a suitable extension shaft for mounting on wheels which are made for either face grinding or edge grinding.

Pneumatic painting or paint sprayer may be used to considerable advantage in and around a boiler shop for painting boilers, tubes, etc., before shipment.

AS AN EXAMPLE of new special uses for the small steam turbine, the Terry Steam Turbine Co. is building an order of slow speed machines for driving sugar separators, these separators heretofoer having been driven either by belt or water motor or direct driven by an electric motor. The turbines will be direct connected to the bottom of the separators and will run at a speed of 2,000 r.p.m.

AN AIR COMPRESSOR'S EXPERIENCE

Holdfast for a Nut that Made More Trouble Than a Loose Nut Could

By Geo. H. Wallace

IT is a deplorable fact that occasionally a purchaser is sold goods on which, either knowingly or not, there has not been put forth the best efforts to turn out a perfect and durable machine. Sometimes it happens that, in the designing of the machine, especially if it is of a new type, the service under which it is to work is not considered.

In a certain plant the demand for compressed air became so great that a new machine was installed of such a size that it would deliver 3 times the volume of free air that existing conditions called for.

Thus the speed of the compressor was so low that there was no undue strain on it when operating. The compressor was of the 2-stage type, with duplex steam cylinders and was known as a 10 and 10 by 16 and 10 by 10 compressor. The 10 by 10 steam cylinders were attached to the main frames with the air cylinders arranged tandem behind them, with a short distance piece between.

Steam and air piston heads were held on the piston rod by means of a taper fit, with a recess, slightly reverse tapered as shown in the cut in each head, into which fitted the nut which held the piston head in place.

The piston rod was 2 in. in diameter at the air end, but only 1¾ in. at the steam end. In order to get the steam piston head on the rod, it was slipped over the rod from the crosshead end and fastened with the nut and the space around the nut filled in with babbit, so as to reduce the clearance as much as possible.

And this was where the weak point occurred. The recess in the steam piston did not have taper enough to hold the babbit and examination showed that possibly the core fell away in casting the head, so that the metal had to be bored out, leaving the inside of the recess so smooth that it would not hold the babbit.

After the machine had been in operation about 2 months, suddenly one day the compressor, while running about 35 r.p.m., stopped, and investigation showed that the crank on the second stage side was on the center and that it required 3 men with a lever 16 ft. long to move the wheel. When started, the machine showed considerable distress, but as air was needed badly the engineer was instructed to keep the compressor in operation for the rest of the day, if possible.

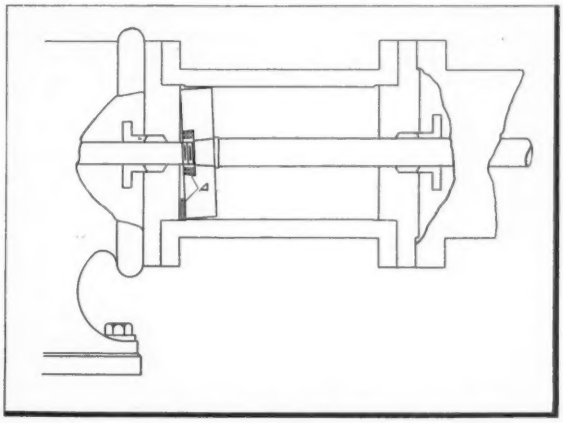
Two hours later, the machine gradually slowed up and stopped and no amount of skill could move it. The distance piece was taken off the side that showed lame and the back steam cylinder head removed; the top and bottom of the inside showed that there was an enormous pressure there. A small try square was inserted and the piston head was seen to be out of square fully $^{3}/_{16}$ in. on the diameter.

It was then a matter of learning the cause of this effect. Believing that the cause was on the other side of the piston, but not knowing just what it was, the engineer disconnected the piping and removing the bolts, slipped the steam cylinder back off the front head and there he found the trouble.

The babbit had cracked radially from the corners of the jamb nut and a sixth of it had worked out and dropped into the clearance space at A and when that crank had crossed the center, this piece of babbit, which was about ⅞ in. square by about 1¼ in. long, was squeezed up to about $^{3}/_{16}$ in. thick and 2 by 3 in. in general dimensions.

One piece having dropped out, the other 5 were quite loose and although they were hard to remove in the limited space it was not thought best to leave them in, so by means of 2 blow torches the remainder of the babbit was melted out when the jamb nut was set up tight and locked with a round nose chisel.

While in this position, it was learned for a certainty that the piston rod was sprung so much as to throw the piston head out of square as shown, and



SECTION OF THE STEAM CYLINDER, SHOWING LOOSE BABBIT AND SPRUNG PISTON

the edges of the piston head rubbing on the walls of the cylinder were what caused the excessive friction.

The compressor was assembled and again put in operation and by using plenty of cylinder oil and graphite, friction was gradually reduced considerable, and air supplied to the factory. In just a week the same thing occurred to the other side, and, knowing the cause, the repairs were soon made and the machine running, but with an enormous friction load.

The manufacturer of the machine was appealed to and finally supplied a set of new piston rods. Replacing of the sprung piston rods was not attended with any great amount of pleasure, but when once placed in operation (without the babbit filling) the engineer said that he had a peace of mind that he never knew before.

A Compressed Air Haulage System has been installed in the mines of the Bergban colliery, New-Essen, Germany, using the exhaust steam from the colliery hoisting engines for running the compressor. The ultimate work of the compressor was the supplying of five pneumatic locomotives each having 170 ton-miles of work per day, the storage pressure required 1470 lb., or 100 atmospheres, and the compression being performed in 4 stages.

The operation of this system has shown that the exhaust steam power, although not as yet fully utilized, is still cheaper than either live steam or electric energy, and it is expected that this fact will be demonstrated to a much more marked degree when it is possible to run the plant at its full capacity.—Compressed Air Magazine.

EVERY-DAY CALCULATIONS

Function of the Flywheel; Calculating Velocity at Which Flywheels Will Burst; Safe Speed and the Weight of Flywheels

By Richard Howarth

FUNCTION OF A FLYWHEEL is somewhat similar to that of the governor, since each is used to obtain regularity of speed. It is the duty of the governor to adjust the effort of the engine to any large or permanent variation of the load; on the other hand it is the duty of the flywheel to adjust the effort of the engine to sudden fluctuations of resistance which may occur during a single stroke of the engine.

It is also the duty of the flywheel to equalize the varying tangential effort on the crankpin by storing energy while the piston is in the middle of the stroke, where

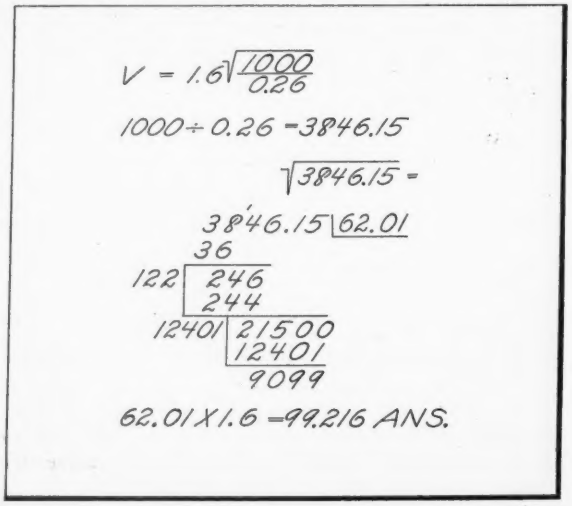


FIG. 1. ARITHMETICAL CALCULATIONS FOR DETERMINING SAFE VELOCITY OF FLYWHEELS

the crank effort is greater than the resistance and restoring it when the crank is at the head point, where the tangential effort is zero.

No matter what materials are used or what the manner of construction, every flywheel will reach a speed where the centrifugal force will cause it to burst. It is well therefore, for the engineer to understand the calculation of the margin of safety when the wheel is running at normal speed. It must be remembered that the stresses in the rim due to centrifugal force increase with the square of the speed.

Safe Velocity of Flywheels

FOLLOWING formula gives the velocity at which any flywheel will burst: $V = 1.6\sqrt{\frac{S}{W}}$ in which V = velocity of rim in ft. per sec.; W = weight of 1 cu. in. of cast iron; S = tensile strength per sq. in. of section. Now if a small test bar of cast iron shows an aultimate tensile strength of 16,000 lb. per sq. in. of section, in large castings we can safely depend on about 10,000 lb. per sq. in. Assuming a factor of safety of 10 we would then have 10,000÷10=1,000 lb. per sq. in., as the safe strength for the rim. The weight of 1 cu. in. of cast iron is approximate 0.26 lb., so that substituting the values in the equation we have for cast iron wheels $V = 1.6\sqrt{\frac{1000}{260.}}$ =99.216 ft. per sec., or approximately 1.12 miles per min., as a safe speed for wheels cast in one piece, but as all cast wheels contain shrinkage strains, good practice is to allow 1 mile per min.

FIG. 2. SLIDE RULE SETTING FOR DETERMINING SAFE VELOCITY OF FLYWHEELS

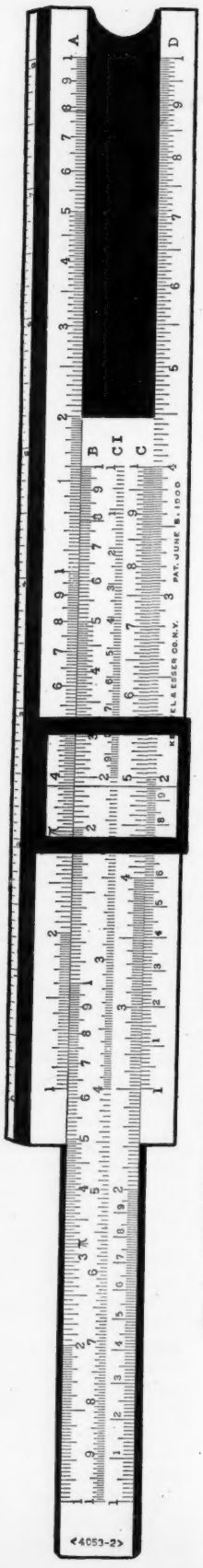


FIG. 4. SLIDE RULE SETTING FOR DETERMINING THE FIRST OPERATION IN CALCULATING THE WEIGHT OF FLYWHEELS

In working out this problem on the slide rule we have to extract the square root, so place 0 26 on B under 1,000 on A, right hand scale; move runner to 1, on B, and the square root of the quotient will be found directly under the hair line on D, which equals 62. Now, leaving 1 on C under hair line on runner, under 1.6 on C find 99.2 on D, which is the safe speed of flywheels in ft. per sec.

Calculating the Weight of Flywheels

TO calculate the weight of flywheels for various kinds of engines use formula $C = \frac{d^2 \times B}{D^2 \times N^2}$ in which C = a constant for various classes of engines; for ordinary slide valve engines C = 350,000, for Corliss engines 700,000 and for automatic high-speed engines 1,000,000; d = diameter of cylinder in inches; B = length of stroke in inches; D = diameter of flywheel in feet; N = r.p.m. What would be the weight of a flywheel for an automatic high-speed engine 24 inches by 24 inches, running at 300 r.p.m. with a flywheel 6 ft. in diameter.

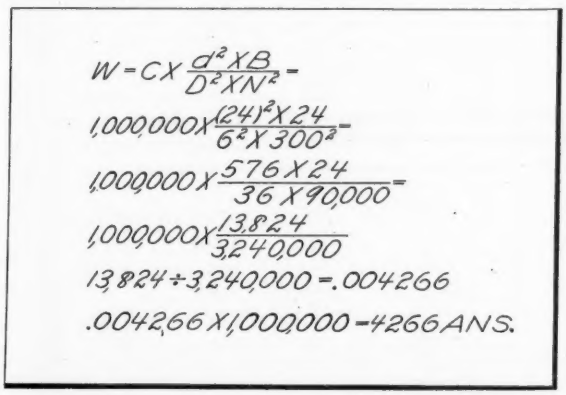


FIG. 3. ARITHMETICAL CALCULATIONS FOR DETERMINING THE WEIGHT OF FLYWHEELS

Substituting figures for symbols we have $W = 1{,}000{,}000 \frac{(24)^2 \times 24}{6^2 \times 300^2} = 4266$ lb., the required weight of the flywheel for this particular engine.

To work out this formula on the slide rule, place 6 on C above 24 on D, move runner to 24 on B, place 3 on C under runner and read 4266 on A above 1 on B.

Brevity of calculations on the slide rule is well illustrated in this example. In the first operation we divide $(24)^2$ by 6^2. We therefore read simply 6 and 24 on the C and D scale and find their square on the B and A scales and look above 1 on B scale to find the quotient on A scale. We next multiply this quotient by 24 by placing the runner over that number on the B scale, the product being found under the runner on the A scale.

The final operation is to divide the last product by 300^2. By placing 3 on the C scale under the runner we find the square on the B scale and the final quotient 4266 on the A scale above 1 on the B scale.

FIG. 4. SLIDE RULE SETTING FOR DETERMINING THE FIRST OPERATION IN CALCULATING THE WEIGHT OF FLYWHEELS

THE MAN WHO TRADES on the ignorance of his fellowmen, or goes on the theory that he knows more than anybody else, and is not going to let anyone into his institution or see what he is doing, generally wakes up some day to find that the world has moved on, and he is only clinging to it by a very percarious tailhold.—Exchange.

UNIFORM BOILER SPECIFICATIONS

I NOTE with pleasure the very full report you give in the issue of April 15, of the work done by the Committee on Uniform Boiler Specifications of the A. B. M. A. at our recent convention in New Orleans.

You suggest that the action regarding heating boilers built entirely of steel seems a bit ambiguous. This as well as all the action referring to the Massachusetts Rules must be taken in connection with the full statement of the Rules themselves. In the case you mention, if the same boiler should be used for heating only at one time, and at another period be required to carry 150 lb. per sq. in. for industrial purposes, it would be treated under 2 separate rules. When used simply for heating, it is not necessary to have a licensed engineer in charge. The restriction that is put on this is not only on account of the boiler, but also on account of the probable capacity of the man in charge. We boiler manufacturers always prefer to have a competent licensed engineer in charge of our boilers. Steam users and sometimes even those who should know better often object to this proviso.

Under the paragraph "Bumped Heads" the change from 0.6 to 0.8 was afterwards reconsidered by the Committee and Council, leaving it exactly as it now is in the Massachusetts Rules, except that the heads are described as externally concave and externally convex, because there was some chance for misunderstanding where the qualifying adverb was not used.

I beg to call your attention to the fact that the work done in New Orleans had necessarily to be done by a portion of the committee which gave in all some 15 hr. of careful study and discussion on certain points which had been brought up by letters from members of the A. B. M. A. It is understood that as soon as the report of the committee is printed and distributed, the entire committee will take it up for further study, and that at some date, not yet fixed, in June the committee will have a meeting in New York City for the purpose of a full consideration of any criticisms or suggestions that may be received from any of our members or from other boiler manufacturers, engineers or steam users.

After this the final report in complete form will be available for the use of any persons interested in boiler construction or inspection. It is the hope of the committee that the A. B. M. A., which commenced this movement for standard rules for boiler construction will everywhere make its influence felt, so that good sound practical rules may be enacted in all the states, and that these will be uniform in all their important provisions.

E. D. Meier.

Chairman Committee on Uniform Specifications, American Boiler Manufacturers' Association.

THE POLARITY OF WIRES can be found by placing the ends of the wires in a common white potato cut into halves. The wires should be placed a small space apart, the distance depending on the voltage. The positive wire of a direct current circuit will turn the potato green and the negative side will remain uncolored. Both ends of the wire on alternating current will turn the potato green. This method can be used in finding the polarities of current from one dry cell up to 500 volts direct current, the only difference is that with very low voltage the wires should be placed in the potato closer together than with higher voltage. In using 110 volts, the time necessary to determine the polarity is about 10 seconds and with a current of 210 volts, about one minute.—Modern Electrics.

Electrical Machinery and Appliances

For Generating, Transmitting and Using Current

ELECTRICITY RECTIFIERS

Why They are Needed, Details of Construction and How They Operate, Efficiency of Conversion

IN several electrical applications direct current either is required for operation or adds to the efficiency. Where only alternating current is available, some means for converting it to direct current has to be provided when direct current is necessary or desirable. If the current demand is large, a rotary converter or motor-generator set is used; for smaller installations the electricity rectifier is coming into quite general use. Primarily it was designed for the charging of storage batteries, but it has found a profitable field in the operation of series arc-lamp circuits in connection with constant-current transformers. Other applications are the operation of focusing lamps for moving picture machines, small motors, etc.

Mercury-Vapor Type

ELECTRICITY rectifiers are divided into 2 general classes, the mercury vapor type as manufactured by the Westinghouse and General Electric Cos. and the graphite-arc valve type, manufactured by the

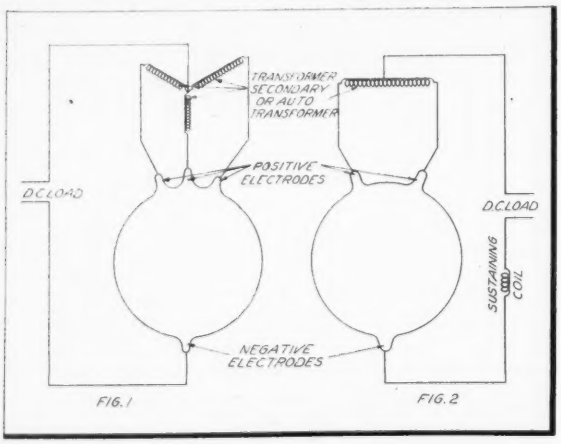


FIG. 1. CIRCUIT DIAGRAM OF 3-PHASE MERCURY-VAPOR CONVERTER

FIG. 2. CIRCUIT DIAGRAM OF A SINGLE-PHASE-MERCURY-VAPOR CONVERTER

Murphy Electricity Rectifier Co. In all types of mercury vapor converters there is one negative electrode connected through the receiving apparatus to the neutral of the supply system, and in addition there are as many positive electrodes as there are main leads in the supply circuit. The active circuit is from the negative electrode continuously to one or another of the other positive electrodes, according to which, at the instant, has positive potential toward the negative electrode. Thus the current is automatically shifted from one of the positive electrodes to another.

3-Phase Connections

FIGURE 1 shows the connections of a 3-phase mercury-vapor converter. There are 3 main positive electrodes and it is evident that when once the apparatus is started it will operate continuously because at no instant can there fail to be an e.m.f. in the right direction upon at least one of the positive electrodes. The converter is usually started by the use of an auxiliary electrode between which and the negative electrode there is formed a mercury vapor path when the glass bulb is properly tilted, either by hand or automatically by means of an electromagnet. Al-

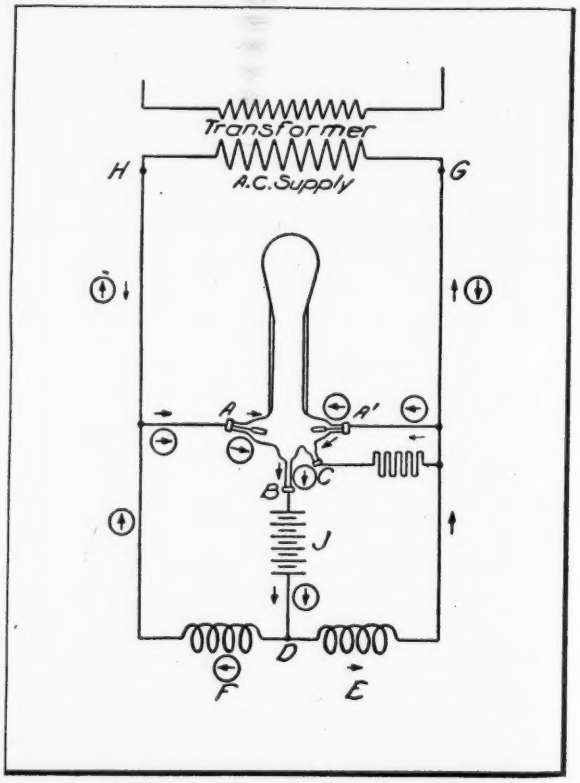


FIG. 3. ELEMENTARY DIAGRAM OF CONNECTIONS OF A MERCURY-VAPOR RECTIFIER CONNECTED TO A BATTERY

though there may exist a considerable e.m.f. between the several positive electrodes, there is no tendency for the current to be established between these electrodes because such action would require the initial reduction of the negative electrode ressitance at a positive electrode.

Single-Phase Converter

ELEMENTARY diagram of connections of a single-phase mercury converter is shown in Fig. 2, in which 2 main positive electrodes are connected to the supply leads and one negative electrode joined through the receiving device to the neutral of the supply system; thus there are substantially 2 single-phase e.m.f's., oppositely directed, connected respectively to the 2 positive electrodes.

In order to prevent the current from being interrupted at the end of the first half cycle before current from the opposite positive could be established, a choke coil, frequently referred to as a sustaining coil, is connected in the negative lead or at any point in the delivery circuit. The result is to delay the decreasing current from one positive electrode until the increasing current in the other is sufficient to maintain the converter alive.

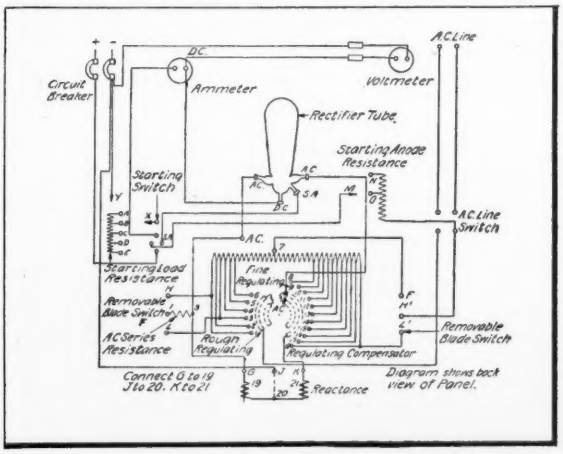


FIG. 4. CONNECTIONS OF A GENERAL ELECTRIC SINGLE-PHASE MERCURY-VAPOR RECTIFIER

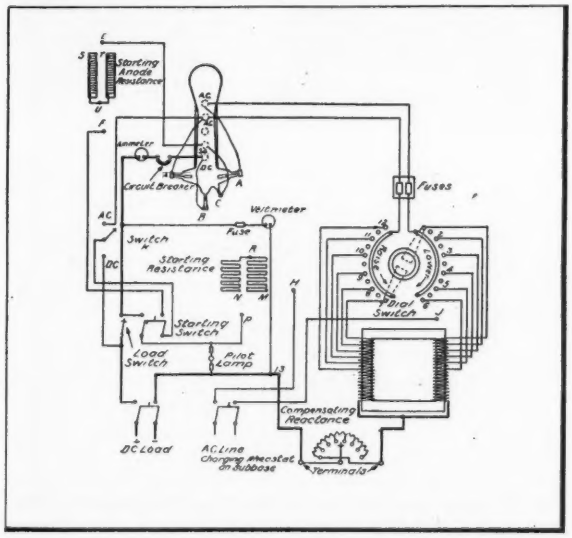


FIG. 5. CONNECTIONS OF GENERAL ELECTRIC MERCURY-VAPOR AUTOMOBILE CHARGING PANEL

A striking characteristic of the mercury-vapor rectifier of either the polyphase or single-phase type is found in the fact that power dissipated in the rectifier is directly proportional to the current and not to the square of the current; that is, regardless of the current the converter consumes a constant e.m.f. of about 15 volts across itself.

The efficiency will remain constant at all loads, except for the effect of the heat losses in the auto-transformer, the sustaining coil, the regulator and other incidental apparatus. Thus not only is the efficiency high at light loads, but the voltage regulation is excellent at all loads. Since the voltage loss is constant, it is evident that the higher the operating voltage the higher the efficiency of the apparatus. For charging batteries the efficiency is about 80 per cent for the complete apparatus when the battery e.m.f. is about 115 volts.

Details of Operation

TO understand the operation of the mercury vapor rectifier more fully, refer to Fig. 3, which gives more detail and shows the various parts used in its construction. The rectifier tube is an exhausted glass vessel in which are 2 graphite electrodes (anodes) A, A′, and one mercury cathode B. Each anode is connected to a separate side of the alternating-current

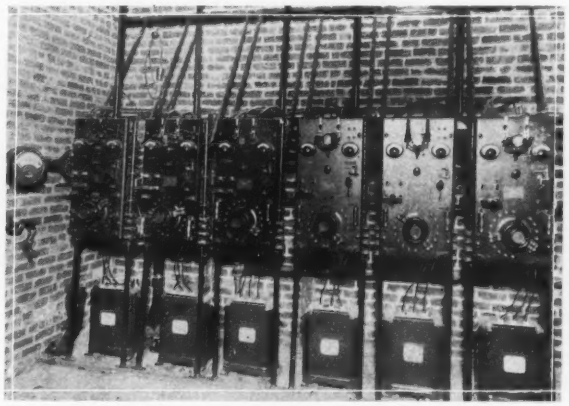


FIG. 6. MERCURY-VAPOR RECTIFIER INSTALLATION

2-phase supply and also through ½ of the main reactance to the negative side of the load. The cathode is connected to the positive side. There is also a small starting electrode, C, connected to one side of the alternating-current circuit to resistance, used for starting the arc.

When the rectifier tube is tilted so as to form and break the mercury bridges between cathode B and the anode C, a slight arc is formed. This starts what is known as the excitation of the tube and the cathode begins to supply ionized mercury vapor. (Here it may be well to explain that ion means one of the elements which appear at the respective poles when a body is subjected to electro-chemical decomposition.) The conditions of excitation can be kept up only as long as there is current flowing toward the cathode. If the direction of supply voltage is reversed with the reversal of the alternating current circuit, so that the formerly negative electrodes or cathodes become positive, the current ceases to flow, since in order to flow in the opposite direction it would require the formation of a new cathode which can be accomplished only by special means therefore, in the restifier tube the current must always flow toward the cathode which is kept in a state of excitation by the current itself.

Such a tube would cease to operate on alternating-current voltage after one-half the cycle, if some means were not provided to maintain the flow of current con-

tinuously toward the cathodes. Maintenance of the current flow is accomplished by the main reactance as the current alternates; first one anode and then the other becomes positive, the current flowing from the positive anode through the mercury vapor toward the cathode, through the battery or other load, in fact, through ½ of the main reactance to the opposite side of the alternating-current supply circuits.

When the current flows through the main reactance it charges it, and while the value of the alternating wave is decreasing, reversing and increasing, the reactance discharges, thus maintaining the arc until the voltage reaches the value required to maintain the current against the counter e.m.f. of the load and reducing the fluctuations in the direct current. In this way a true continuous current is produced with very little loss of transformation. That there may be no

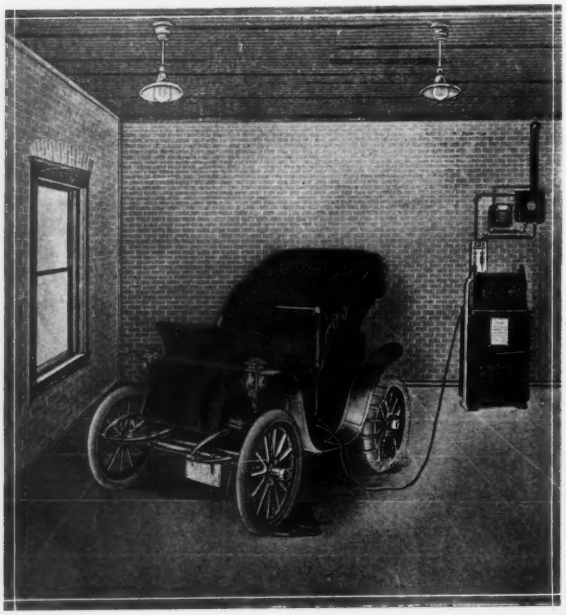


FIG. 7. WESTINGHOUSE MERCURY-VAPOR RECTIFIER AS USED IN CHARGING AN AUTOMOBILE

misapprehension, particular attention is called to the fact that the rectifier is so designed that the entire alternating current wave is used. This, of course, means that the rectifier has approximately twice the efficiency that would be obtained if only ½ of the alternating current waves were used.

To get an idea of the operation of the mercury-vapor rectifier, assume the instant that the terminal H of the supply transformer is positive; the anode A is then positive, and the arc is free to flow between A and B. Following the direction of the arrow still further, the current passes through the battery J, through ½ of the main reactance coil E, and back to the negative terminal G of the transformer. When the impressed e.m.f. falls below a value sufficient to maintain the arc against the counter e.m.f. of the arc and load, the reactance E, which heretofore has been charging, discharges, the discharged current being in the same direction as formerly. This serves to maintain the arc in the rectifier tube until the e.m.f. of the supply has passed through zero, reversed and built up to such a value as to cause the anode A to have a sufficient positive value to stop the arc between it and the cathode B.

Discharge circuit of the reactance coil E is now through the arc A′B, instead of through its former circuit, consequently the arc A′B is now supplied with current partly from the transformer and partly from the reactance coil E. The new circuit from the transformer is indicated by the arrows inclosed in circles. The reactance is essential to the successful operation of the rectifier, as its function is to maintain the arc in the tube while the alternating current is passing through the zero point of the cycle.

This reactance is connected between the anodes of the tube and across the secondary of the regulating compensator. It consists of 2 coils connected in series and wound upon 2 legs of a rectangular laminated iron core and is enclosed in a cast-iron case. The 3 leads are brought out through the top of the case. Two come from the end of the coil and one from the series connection of the 2 coils. The middle lead of the series connection of the coils is used as the negative of the direct current circuit, while the cathode of the tube is the positive pole.

Fine and coarse regulation of the direct-current voltage is accomplished by means of a regulating compensator, certain taps of which are connected across the alternating-current line, while other taps are connected through dials which reach across the anodes of the tube. This compensator consists of a coil wound upon one leg of a rectangular laminated iron core. The coil has 18 taps brought out; 17 of these are connected

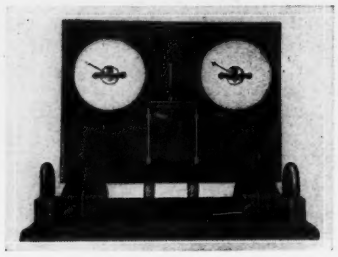


FIG. 9. INSTRUMENT PANEL FOR MERCURY RECTIFIER

FIG. 8. TIME SWITCH FOR MERCURY RECTIFIER

to studs on a dial switch and the remaining ones to the upper studs of the single-pole double-throw movable blade switch, as seen in the diagram of connections, Figs. 4 and 5.

Converter Panels

FIGURE 6 shows a group of General Electric rectifier panels in a large garage. On the front of each panel the following apparatus is mounted. Double-pole circuit breaker, ammeter, voltmeter, single-pole double-throw combined starter and load switch, single-pole single-throw auxiliary switch for starting anode circut, double-pole single-throw switch for alternating-current line, a 6-point and an 11-point switch controlled by lever arm, 2 single-pole double-throw removable blade switch clips with blades and a hand wheel for tube holder. On the back of the panel are located the tube holder, starting load resistance, starting anode resistance, regulating compensator, alternating-current series resistance, wiring, meter fuses, etc.

Figure 7 shows a Westinghouse mercury-vapor rectifier. The outfit consists of a Cooper-Hewitt mercury rectifier bulb and a stationary regulating apparatus, all contained in a ventilated iron case. At the top of the case are 2 dial switches for regulating the charging current, and a knob for starting the charge. If the batteries are to be charged at night when the usual attendant is not available, a time switch shown in Fig. 8, may be used to terminate the charge at a predetermined time. If the charge is not complete it can be finished in a comparatively short time when the attendant arrives. The meter panel, consisting of a slate base on which are mounted an ammeter, a volt meter and a line switch is illustrated in Fig. 8.

Graphite-Arc Type

A MURPHY electricity rectifier is shown in Fig. 10. It consists essentially of a graphite-arc valve which has an infinite resistance for current in one direction, but for current in the other direction a negligible re-

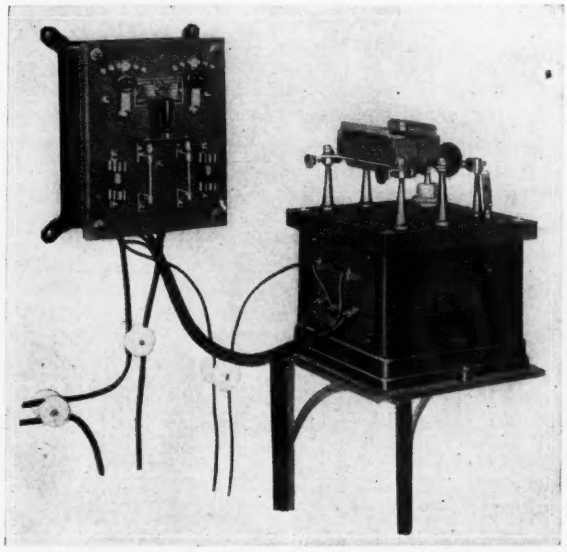


FIG. 10. MURPHY ELECTRICITY RECTIFIER

sistance. This difference in resistance is obtained by breaking down in one direction only by means of a high tension disruptive discharge, the resistance formed by air and gas between graphite electrodes.

In operation, the high-tension discharge closes the graphite-arc valve, which is connected in series with the alternating supply current and the direct current load; then the load current follows the low resistance of the arc as established by the high-tension discharge, and forms an arc which maintains itself until extinguished by the dropping of the impressed voltage near the end of the half cycle.

The diagram of connections is shown in Fig. 11, and curves of an efficiency test in Fig. 12. The disruptive discharge is furnished by an auxiliary circuit containing a small high-tension transformer, a condenser and an auxiliary spark gap. One terminal of the auxiliary spark gap is a nickel disk, the other a loop of platinum-iridium wire heated to a dull red heat by an auxiliary secondary winding on the transformer. Under this condition, this loop tends to throw off negative ions, and this action lessens the resistance to current flowing in their direction and increases the resistance to current flowing in the opposite direction.

The auxiliary spark gap is adjusted so that the e.m.f. of the high-tension transformer alone will not quite establish the arc across the gap; but with the assistance of the stream of negative ions the arc is

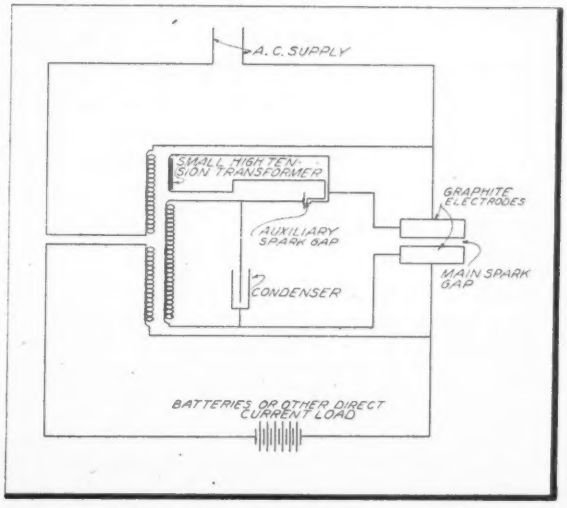


FIG. 11. DIAGRAM OF CONNECTIONS OF MURPHY ELECTRICITY RECTIFIER

established and the current flows in the same direction at every other half cycle. To aid the valve action at the spark gap further, the transformer is excited by both a.c. and d.c. currents, which results in a higher voltage during every other half cycle. When the current flows in the opposite direction during the other half of the cycle, the voltage in the auxiliary cir-

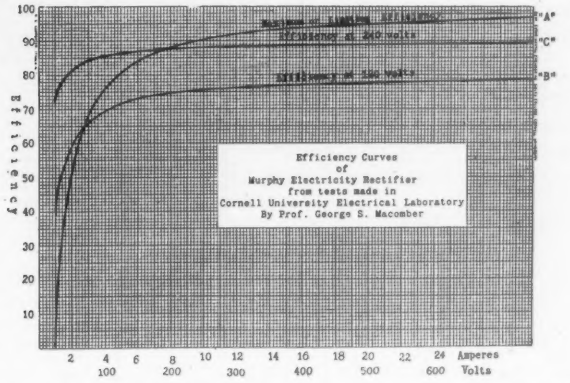


FIG. 12. EFFICIENCY CURVES OF MURPHY ELECTRICITY RECTIFIER

cuit is not sufficient to establish the arc and no current will pass the graphite electrode. The result is an intermittent flow of current in one direction only in the battery circuit.

THE PLACE THAT aluminum has found in the arts is shown by the increase in production from 83 lb. in 1883 to nearly 50,000,000 lb. in 1911.

COPPER PRODUCTION in 1911 in the United States, according to the Bulletin of the U. S. Geological Survey reached 1,097,232,749 lb., the largest for any year in the history of the industry. Home consumption was somewhat smaller than for previous years, but exports were considerably larger so that stocks on hand were reduced.

ENGINE TEST FROM THE INDICATOR DIAGRAM*

Determination of Clearance, Leakage, Valve Setting and Steam Used, by the Use of Logarithmic Section Paper; Where the Slide Rule Comes in Handy

By J. Paul Clayton

FROM EXTENSIVE EXPERIMENTAL STUDY of the forms of the expansion and compression curves which occur in indicator diagrams has been developed a new and very complete analysis of cylinder performance for reciprocating engines using any elastic fluid for the working medium.

Analytical study was carried on by transferring the indicator diagram to logarithmic cross-section paper and thus drawing a figure which will be called logarithmic diagram. It is well known that the curve whose equation is $PV^n = C$ becomes a straight line when plotted on logarithmic cross-section paper. Conversely, when the expansion or compression curve of an indicator diagram becomes a straight line in the logarithmic diagram, then the curve has an equation of the form $PV^n = C$, the value of n being the slope of the line or the ratio of rise to horizontal on any given portion of the line.

The logarithmic diagram is more useful for analysis than any other form because of the natural limitations of the human mind. We do not possess the power to distinguish between curves, but are able to see clearly the differences in these curves after they have been transformed into straight lines, which fact alone makes these new methods of analysis possible. We are now enabled in their straight-line form to comprehend curves which we have always seen, but could not distinguish one from the other in their original form.

The engine used for the experimental work was a 12 by 24-in. Corliss with long range cutoff in the University of Illinois laboratory, a large number of tests being run as explained later. Data of the engine and diagrams are as follows:

	Head End	Crank End
Length of indicator diagram, in.	3.95	3.99
Ratio of Clearance to piston displacement, same end	0.0789	0.0704
Length on diagram proportional to clearance ratio, in.	0.312	0.281
Length of diagram, plus clearance, in.	4.26	4.27
Piston displacement (cylinder 12.02 in. by 24 in.), cu. ft.	1.575	1.523
Clearance volume, cu. ft.	0.124	0.107
Displacement plus clearance, total volume, cu. ft.	1.699	1.630
Ratio, cu. ft. per in. of length on diagram, cu. ft.	0.399	0.382
Scale of indicator spring per in. of ordinate, lb.	77.0	79.0

Method of Constructing the Logarithmic Diagram

THE logarithmic cross-section paper used in this investigation consists of 4 squares arranged 2 each way. These squares are 5 in. each way, making the 4 squares together 10 in. each way. The use of 4 squares enables values to be plotted ranging from 0.1 to 10.0, 1.0 to 100.0, etc., thus giving a range of 10 times the values obtainable if only one square were used.

*From a paper to be read before the American Society of Mechanical Engineers at Cleveland, O., May 27-31.

The division of the paper is on a logarithmic scale like that used on the slide rule. Height and length of the PV-diagram are proportional to pressure and stroke, the latter being proportional to the volume displaced by the piston. The co-ordinates of several points on the PV-diagram are found in terms of absolute pressure, preferably in pounds per square inch, and absolute volume, preferably in cubic feet, as these are the units used in steam tables.

Transferring the PV-diagram to the logarithmic form is described in detail for the diagrams given in Fig. 1, especially for the crank end. The diagram is shown in outline by ABYX. Perpendiculars QR and EX are drawn to the atmospheric line EQ, and pass through the extreme stroke positions of the diagram. The distance EQ is then the length of the diagram.

OM is laid off perpendicular to the atmospheric line EQ (extended) which was drawn by the indicator pencil. OM is the line of zero volume, and is drawn at a distance

TABLE I. CONSTRUCTION OF THE LOGARITHMIC DIAGRAMS OF FIG. 1

Number	Head End: Absolute Pressures, lb. per Sq. In.	Head End: Volumes In. Compression* X to A	Head End: Volumes In. Expansion* Y to B	Head End: Volumes Cu. Ft. Compression	Head End: Volumes Cu. Ft. Expansion	Crank End: Absolute Pressures, lb. per Sq. In.	Crank End: Volumes In. Compression	Crank End: Volumes In. Expansion	Crank End: Volumes Cu. Ft. Compression	Crank End: Volumes Cu. Ft. Expansion
1	133 0	0·39	1.18	0.156	0.470	134 3	0 30	1 205	0.115	0 4605
2	113 4	0 31	1.36	0.124	0.5425	115 3	0 28	1 39	0 107	0 534
3	95 0	0 31	1.625	0.124	0.649	96 3	0 28	1 65	0 107	0 6305
4	76 3	0 31	2.02	0.124	0 8055	77 3	0 28	2 06	0 107	0 7875
5	57 1	0 31	2.705	0 124	1.080	58 1	0 295	2 76	0.113	1 055
6	38 9	0 375	4.03	0.150	1 610	38 7	0 385	4 12	0.147	1 572
7	29 4	0 48	4.22	0.192	1 685	29 1	0 485	4 26	0 185	1 626
8	19 5	0 70	4 26	0 279	1 699	19 8	0 66	4 20	0 252	1 600
9	15 0	1 10	3 06	0 439	1 220	15 0	0 93	3 77	0 355	1 440

* Letters refer to Fig. 15, Crank End.
† Final results given in Table I.

FE from the admission end EX of the diagram, the distance FE being the same length in per cent of the line EQ, or length of the diagram, as the proportion that the per cent of clearance, or waste space, of the cylinder bears to the piston displacement. In this case the length of the diagram was 3.99 in., and the clearance was 7.04 per cent. The length FE was therefore 0.0704 multiplied by 3.99, or 0.281 in.

ON is the line of zero pressure and is drawn a distance FO below the atmospheric line, to the scale of the spring used in obtaining the PV-diagram in this case 79 lb. per in. This distance is proportional to the barometer reading, corrected for temperature, prevailing at the day and place of the engine test. In this case the corrected barometer reading was 14.2 lb. per sq. in. absolute, so the distance FO is $14.2 \div 79$ or 0.18 in.

From ON points are laid off on QR and EX corresponding to the absolute pressures at the intervals where it is desired to read off the corresponding volumes. Fine lines are drawn connecting similar pressure points, as 19.8-19.8, 29.1-29.1, etc. The volumes G-A, G-B, H-D, H-C, etc., are read off in hundredths of an inch to the nearest half hundredth. The tabular form used in this investigation is given in Table I for the diagrams of Fig. 1. Thus the length G-A is read off as 0.66 in., and is given under the column for 19.8 lb. pressure, headed Compression, for the crank end diagram. The volumes in inches

are then multiplied by the constant ratio which 1 in. of length of the diagram bears to the displacement of the piston.

Piston displacement for the crank end is 1.523 cu. ft., and the length of diagram 3.99 in., hence, the ratio is 1.523 ÷ 3.99 or 0.382 cu. ft. of piston displacement per inch of diagram length. The length G-A in cu. ft. of displacement now becomes 0.66 multiplied by 0.382, or 0.252 cu. ft., the volume of steam present at this point. This process is repeated at intervals until the co-ordinates of from 10 to 30 points are determined. In the diagram shown in Fig. 1, the co-ordinates of 18 points were found in each diagram.

Slide Rule Multiplication by a Constant

N figuring the values for volumes in cubic feet, the slide rule is of the greatest help. The various lengths in inches as measured on the crank end diagram all have to be converted into the volume represented in cubic feet by multiplying by the constant 0.382.

Set 1 on the B scale to 382 on A scale and by placing the runner at 3 on B we get 1146 or 0.115, the first compression value for the crank end. Runner to 1205 on B gives 0.46 on A, the first expansion value. Runner to 28 on B gives 0.107 on A, the second compression value; and so on. By moving the runner and reading, all multiplications are performed without change of the slide.

To find the value of the constant for the head end, we have, piston displacement = 1.575 cu. ft.; diagram length = 3.95 in. Constant = 1.575 ÷ 3.95.

Set runner to 1575 on A and bring 395 on B to the runner. This leaves 1 on B under 0.399, which is the constant multiplier and values for the head end volume in cubic feet are found by use of the runner and the inches representing volume the same as for the crank end.

The co-ordinates of P and V are then plotted on

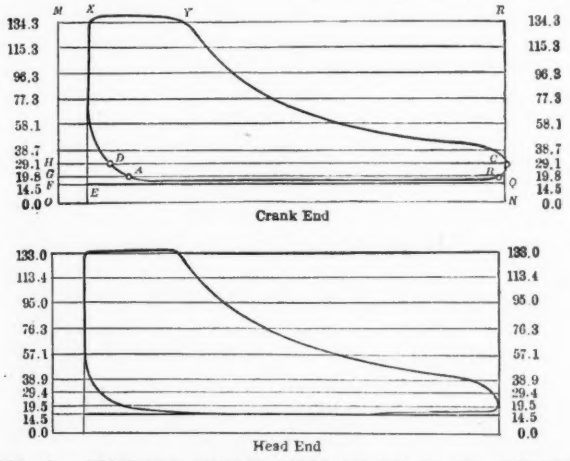


FIG. 1. DIAGRAMS TAKEN FROM 12 BY 24 IN. CORLISS ENGINE IN UNIVERSITY OF ILLINOIS LABORATORIES

logarithmic cross-section paper, as shown in Fig. 2, which are the logarithmic diagrams derived from the PV-diagrams of Fig. 1. The points plotted in Fig. 1 are taken from the columns headed Cu. Ft. at the pressure shown. A smooth curve is drawn through the points thus plotted, and the diagram is in shape to be studied.

Determining Clearance

FROM the fact that the law $PV^n = C$ holds for expansion and compression curves from practice, there have been developed rational methods of approximating the clearance volume, of closely locating the events of the stroke, and of detecting moderate leakage when the engine is in regular operation. These methods apply, however, only to those indicator diagrams which are taken from the cylinders of reciprocating engines using any elastic fluid for the working medium and having as a part of the cycle an expansion or compression of the medium.

It has been discovered that the value of n for the expansion curves of steam diagrams bears a definite relation in any given cylinder to the proportion of the total weight of steam mixture which was present as steam at cutoff. This proportion or quality will be called X, and its value will be expressed in decimal parts of unity. The relation of the value of n to the value of X for cylinders with like jacketing has been found to be practically independent of engine speed and of cylinder size.

The practical significance of finding this relation is that there is now available an accurate method of ap-

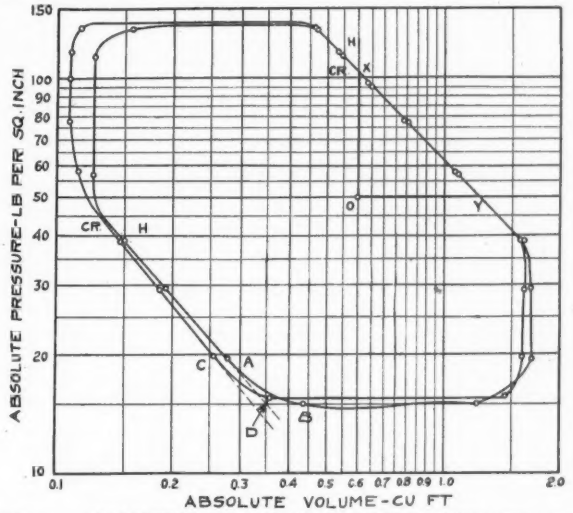


FIG. 2. LOGARITHMIC DIAGRAMS PLOTTED FROM FIG. 1.

proximating the value of X and therefore the actual weight of steam and water present at cutoff from the indicator diagram alone.

Preliminary to the investigation, an examination was made of the nature and form of the expansion and compression curves from a large number of steam engines, by the aid of the logarithmic diagram.

Values of n exhibited a large range of variation, from 0.7 to 1.34. The engines from which the values were obtained differed in type, size, speed, steam pressure, ratio of expansion and back pressure. Obviously, comparisons could not be made of these examples because of the number and magnitude of the variables.

Indicator diagrams taken from the same cylinder with different cutoff positions showed that the value of n was higher as the cutoff was lengthened. There was a large variation in the value of n where the conditions of cylinder size, speed, steam pressure and steam distribution were the same. The only variable shown by the diagrams was length of the cutoff. After considerable study, it was decided that there might be some relation in any one cylinder between the value of n for the expansion curve and the value of X, as the value X was known to be higher as the length of cutoff increased. One fact that seemed to confirm this hypothesis was that, with superheated steam (under the same general conditions, except the kind of steam used), when the value of X is high, the value of n for expansion is always much higher than

with saturated steam. The only important variable between the use of saturated and superheated steam to account for the change in the value of n was the quality of the steam mixture at cutoff, or the value of X.

All cases of engines examined using superheated steam at normal cutoff showed n to be higher than 1, and as high as 1.34; and all cases of small engines using saturated steam showed n to be lower than 1 and as low as 0.7. These facts led to the conclusion that the value of X was the most important single factor in the accompanying value of n. Tests were therefore planned in which the effort was made to vary the value of X between the widest practicable limits.

Laboratory Tests

IT was planned to observe the effect upon the value of n of varying the value of X under different conditions of pressure and speed. The value of X was varied by the use of saturated and superheated steam, in conjunction with different lengths of cutoff under the same conditions of pressure and speed. The values of X obtained ranged from 0.5 to 0.9, covering the range usually found in practice with the type of engine used.

Values of n for the expansion curves were obtained by means of the logarithmic diagram already explained. Seventy-four tests were run, of which 60 were selected as fulfilling the requirements decided upon to give reliable data. Each series consisted of 4 to 5 separate tests,

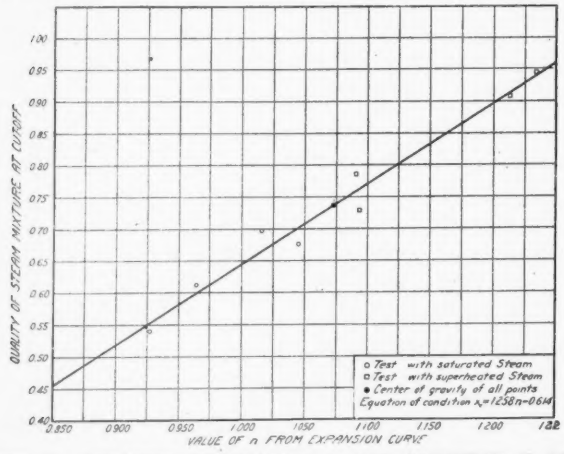

QUALITY OF STEAM MIXTURE AT CUTOFF
VALUE OF n FROM EXPANSION CURVE
o Test with saturated Steam
o Test with superheated Steam
• Center of gravity of all points
Equation of condition x=1.258n-0.614

FIG. 3. RELATION OF QUALITY X AND EXPONENT N AT PRESSURE OF 111 LB. ABSOLUTE AT CUTOFF AND 150 R.P.M.

differing from each other only in the length of cutoff, with the same conditions of pressure and speed. All tests were run with the steam exhausting from the cylinder at about atmospheric pressure into a surface condenser. The length of cutoff was varied in nearly uniform steps from about 5 per cent to 45 per cent of the length of the stroke and was the means of varying the value of X when using either saturated or superheated steam.

Seven tests of a series were run with saturated steam, and another with steam superheated to 500 deg. F. at the superheater. The steam pressures used were 57.5, 76.5, 95, 113, and 132 lb. gage with the engine running at 120 r.p.m. The other speeds employed were 90 and 150 r.p.m. at the gage pressure of 113 lb. Each division, therefore, gave the effect of the use of 5 steam pressures at constant speed, and 3 speeds at constant pressure.

All the simultaneous values of X and n obtained from the 60 tests were plotted and a study of this figure showed beyond question that as X increases in value, n increases also.

The points occupy a relatively wide region until they are separated into the various groups of similar pressures and speeds.

The points for each group were plotted separately, and separate curves were determined for each condition. From preliminary plotting, the relations between n and X were found to be expressed closer by straight lines than by any other family of curves. The method used to draw these lines will be given for one group, which includes 4 tests, at 113.5 lb. gage at the throttle with saturated steam, and 4 tests at 112.4 lb. gage at the throttle with superheated steam. This group is shown in Fig. 3. All points were given equal weight. The average of all the co-ordinates, or the "center of gravity" was found and the conditions imposed that the line pass through this center as an axis, and that the slope be determined by the position of the points. The straight line, in most cases, represents the points found as close as any other curve that could be employed, and has the merit of simplifying greatly the subsequent use made of the relations for the different groups.

The points show that for each initial condition of steam the value of n increased as the cutoff was lengthened, and that with any given cutoff different values of n were obtained according as saturated or superheated steam was used. Thus at a cutoff of 15 per cent, the value of n obtained is 0.950 with saturated steam, and 1.084 with superheated steam. The only variable present in these 2 cases is X, the value of which is higher with superheated steam than with saturated steam. A definite relation between n and the length of cutoff occurs only when a given cutoff is accompanied by the same value of X, that is, the value of n bears a direct relation to X but not to cutoff.

Effect of Varying Steam Pressure and Speed

BY the method outlined for Fig. 3, the relation of X and n was determined for all groups, and examination made to find the effect of varying the absolute pressure at cutoff. The effect is not great between the limits of 75 and 150 lb. At an average pressure of 129 lb. the relation is represented by the equation: $X = 1.245n - 0.576$.

Examination was similarly made for the effect of speed and, although the data were not sufficiently complete to be satisfactory, the change in speed did not seem to affect seriously the relations of X and n.

As a final conclusion from the tests, it may be stated positively that there is a definite relation, for any given engine, between X and n, which, between the limits examined, is practically independent of the cutoff, which varies to some slight extent with absolute pressure and speed, and which nearly enough for practical purposes is expressed by a straight line.

Approximate Actual Steam Consumption from Indicator Diagrams

WHEN indicator diagrams were first obtained from steam engines, loss from initial condensation was not suspected and it was believed that the steam consumption could be determined from the diagram at the point of cutoff. Tests of Clark and Isherwood revealed the existence and amount of this initial condensation, but the great difference in the proportion that the initial condensation bears to the total weight of mixture present, either at cutoff or during the expansion, as found in different types and sizes of engines, has prevented any reliable determinations of the actual steam consumption by this method. The steam consumption computed from the diagram, when using saturated steam, is generally from 15 per cent to 50 per cent below the actual consumption.

After many examinations into the cases of different types and sizes of engines, with nonjacketed cylinders in good order, and with pressure limits similar to those used with the tests, it has been found that while the initial condensation is subject to the action of 10 or more variables, yet the value of n resulting from a given value of X is almost always substantially the same. Cylinder sizes examined varied from 10½ by 12 in. to 34.2 by 60 in., the speeds from 48 to 263 r.p.m., and the types include slow-speed Corliss, high-speed, and locomotive engines. The possibility of calculating accurately the weight of condensation in these different cases may be easily imagined.

These examinations and comparisons, together with a study of the action of steam in condensing during admission and re-evaporating during expansion showed that the relation between X and n as shown by the equation already given holds within a small percentage of error for nonjacketed cylinders on any type or size of engine for speeds and pressures within the range examined.

It appears, therefore, that this method of approximating the value of X at cutoff from experimentally determined relations, and thus accounting for the initial condensation, is upon much surer ground than any method of computing condensation from the physical facts surrounding the case.

This method is free from several objections to which tests are open. It measures the consumption in one revolution, and is, therefore, practically measuring a rate instead of a quantity. The only data needed for an approximation are one set of indicator diagrams, taken simultaneously, the constants of size and clearance, and the speed of the engine tested. No interruption of any kind in the routine of a plant is caused, and the expense incurred is not to be compared with that of an equally accurate test. The method is accurate enough for almost all purposes except guarantee tests subject to bonus and forfeit contracts.

In the case of locomotives on the road, it is the only possible method of approximating the steam consumption of the main engines, due to the use of steam by the air-pump, train-heating system, blower, generator sets, safety valves, whistle, blowoff valves, and leaks. The same is true of marine engines, where many auxiliaries are supplied with steam from the same boilers, and exhaust into the same surface condensers. The method is especially useful for noncondensing engines, where the boiler-feed measurement method is the only practicable one. Steam consumption may be obtained as often as is desired instead of probably once in an engine's life.

Limitations

THE relations of X and n given in Fig. 4 are applicable, however, only to nonjacketed cylinders exhausting at very close to atmospheric pressure. When the back pressure is raised to 30 lb. absolute, for instance, there is a new series of relations existing for the same initial pressure, due to a different temperature range in the cylinder and the consequent alteration of the phenomena occurring after cutoff. Steam jackets also alter the phenomena occurring after cutoff, and therefore have to be examined separately for the relations of X and n.

Since this method rests entirely on the indicator diagram, great care must be observed in taking these diagrams. The indicator itself must be an accurate instrument in the best possible condition. The indicator connections must be short and direct. An extensive investigation by Dr. W. F. M. Goss shows that the long and indirect pipe connections materially alter the form and character of the expansion curves. A correct reducing motion, free from lost motion, must be used so as to reproduce the actual expansion. The arrangement of having one indicator at each end of the cylinder is always to be preferred.

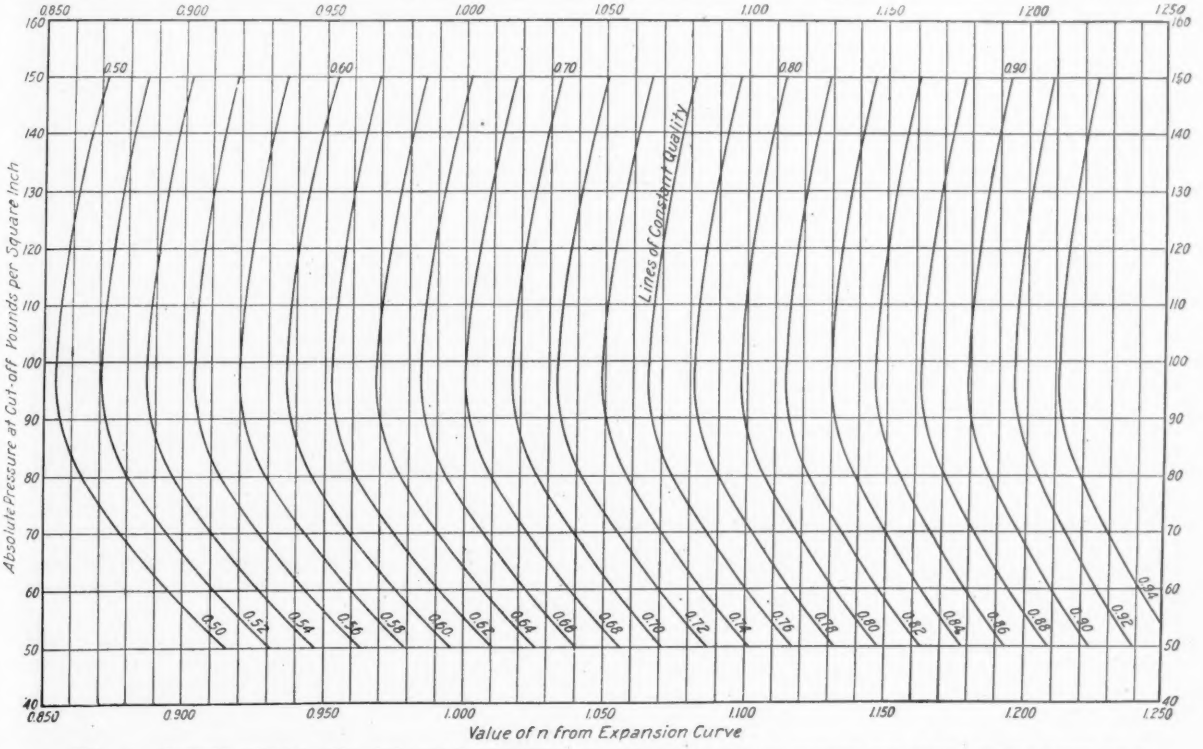


FIG. 4. CURVES GIVING THE RELATION BETWEEN N AND PRESSURE AT CUTOFF FOR DIFFERENT VALUES OF X

Applications of this method must be made with judgment and care. If large leakage exists, only an approximate solution can be obtained, as certain assumptions, treated in the section of leakage, have to be made. The various steps involved in the use of the method must be thoroughly comprehended to give satisfaction.

Application of the Method

RELATIONS of X and n, as determined for various pressures at constant speed from the engine tested in the laboratory of the University of Illinois were plotted in the form of the chart shown in Fig. 4.

The next step was to examine, with certain restrictions, the tests of other engines, and to compare the relations of X and n with those given in Fig. 4. The restricting conditions imposed were: that the tests should come from reliable sources that the data supplied should be complete enough for computing the quantities needed for comparison; that the cylinders should be nonjacketed; that the diagrams furnished should be representative of average conditions; that the back pressure in the cylinder examined should be practically atmospheric; that no large leaks should exist.

The values of X, n and p were first found from the set of diagrams to be examined. Next, the values of n and p were located in Fig. 4 and the corresponding value of X found, as obtained in the tests. The value of X obtained from the chart and that obtained from the test examined were compared, and the steam consumption, as computed by the value of X taken from the chart, was obtained.

Four distinct classes of engines were examined. These include simple Corliss, 2-valve and 4-valve types, the high-pressure cylinders of compound engines, the intermediate-pressure cylinders of triple expansion engines, high-speed and simple locomotive engines.

The final results were averaged and the averages showed an average error in X as approximated from the chart, Fig. 4, of 3.06 per cent and in steam consumption of 3.72 per cent, when compared with the results from tests. For X as approximated from the equation, $X = 1.245n - 0.576$, the average error was 3.32 per cent and for steam consumption 3.98 per cent when compared with test results. For one analysis in which the conditions of the engine were far outside the range examined in the University of Illinois tests, viz., speed 27.7 r.p.m. and pressure at cutoff 38.5 lb. absolute, the error in X as computed from the chart was 7.5 per cent, not an unreasonable amount when the difference in conditions is considered.

The results of the applications made up to the present, with the restricting conditions imposed, tend to show that the steam consumption of engines may be approximated from the indicator diagram to within an average difference of less than 4 per cent from the test results.

Application to All Elastic Media

AS a result of investigation of some 300 indicator diagrams from cylinders using steam, air, gas and ammonia, it may be stated that the equation $PV^n = C$ holds for practically all elastic media.

The logarithmic diagram previously described forms, therefore, the basis of the methods of analyzing the cylinder performance of reciprocating engines which are hereafter developed in detail.

These methods apply only, however, to the logarithmic diagrams derived from the cylinders of reciprocating machines using an elastic fluid for the working medium and having, as a part of the cycle of operation, an expansion, a compression, or both.

(To be Continued.)

RELATIONS BETWEEN DIAMETER AND SPEED OF PULLEYS AND GEARS

By John B. Sperry

IF motion be transmitted from one pulley to another by means of a thin non-stretchable belt and without slip, every part of the latter will have the same velocity, and the outer surface of the rim of each pulley will have the same velocity as the belt. This fact enables us to derive a formula for the relations of the speeds of 2 pulleys with their diameters. Let D_1 = diameter of the driver, D_2 = diameter of the driven, N_1 = r.p.m. of the driver, N_2 = r.p.m. of the driven. Then $D_1 \times N_1 \times 3.1416 = D_2 \times N_2 \times 3.1416$

$$\frac{D_1}{D_2} = \frac{N_2}{N_1}$$

In the calculation of pulley speeds 4 different problems are possible.

Problem 1. The diameter of the driven pulley and its revolutions and also the revolutions of the driver being given, to find the diameter of the driver:

$$\frac{D_2 \times N_2}{N_1} = D_1$$

Problem 2. The revolutions of the driven pulley and also the diameter and revolutions of the driver being given, to find the revolutions of the driver:

$$\frac{D_1 \times N_1}{N_2} = D_2$$

Problem 3. The diameter and revolutions of the driven pulley and also the diameter of the driver being given, to find the revolutions of the driver:

$$\frac{D_2 \times N_2}{D_1} = N_1$$

Problem 4. The diameter and revolutions of the driver, and also the diameter of the driven being given, to find the revolutions of the driven:

$$\frac{D_1 \times N_1}{D_2} = N_2$$

If the above formulas are used for gears, the number of teeth in the gears must be substituted wherever the diameter occurs.

These rules are theoretically correct, though owing to the slip, elasticity and thickness of the belt, the circumference of the driven pulley seldom runs as fast as that of the driver. Belts, like gears have a pitch-line, or a circumference of uniform motion. This circumference is within the thickness of the belt and must be considered if the pulleys differ greatly in diameter and a required speed is absolutely necessary.

The accompanying diagram was designed to solve the above formulas by inspection. Referring to the diagram, we find along the lower margin 4 lines of figures. These represent revolutions per minute laid off to different scales. Along the top margin there are also 4 lines of figures that represent diameters laid off to different scales. Radiating from the lower left hand corner are lines that represent diameters, and from the lower right hand corner are lines that represent revolutions per minute. Examples:

Example 1. Given: Diameter of the driven, 8 in., speed of the driven = 300 r.p.m., speed of the driver = 40 r.p.m. To find the diameter of the driver:

Solution:—Start from 300 in the third line of figures at the lower margin and project up to the 8-in. line, from there across to the 40-revolution line, and then up to the third line of figures at the top where we find the result to be 60 in.

Example 2. Given:—Diameter of the driver = 18 in.; speed of the driver = 60 r.p.m.; speed of the driven = 180 r.p.m. To find diameter of the driver:

Solution:—Start from 16 in the top line of figures at the lower margin and project up to the 18-in line, from there across to the 180-revolution line, and then up again to the first line of figures at the top, where the answer is found to be 6 in.

Example 3. Given:—Diameter of the driven = 16 in.; speed of the driven = 240 r.p.m.; diameter of the driver = 9 in. To find the speed of the driver:

Solution:—Start from 16 in the top line of figures at the top margin, and trace downward until the 240-revolution line is reached, from there, crosswise to the 9-in. line, and then down to the bottom, where the result is found to be 427 r.p.m.

Example 4. Given:—Diameter of the driver = 36 in.; speed of the driver = 70 r.p.m.; diameter of the driven = 8 in. To find the speed of the driven.

Solution:—Start at the top again, this time from 36 and project down the 70 revolution line. From there across to the 8-in. line, and then to the bottom where the answer is found to be 300 r.p.m.

When using the diagram for gear ratios the number of teeth must be substituted for the diameter.

Example 5. Given:—Number of teeth of the driver = 24; speed of the driver = 80 r.p.m.; number of teeth of the driven = 14. To find revolutions of the driven:

Solution:—Starting from 24 in the second line of figures at the top margin, follow down to the 80-revolution line, from there across to the 14 line, and then downward again, and the result is 137 r.p.m.

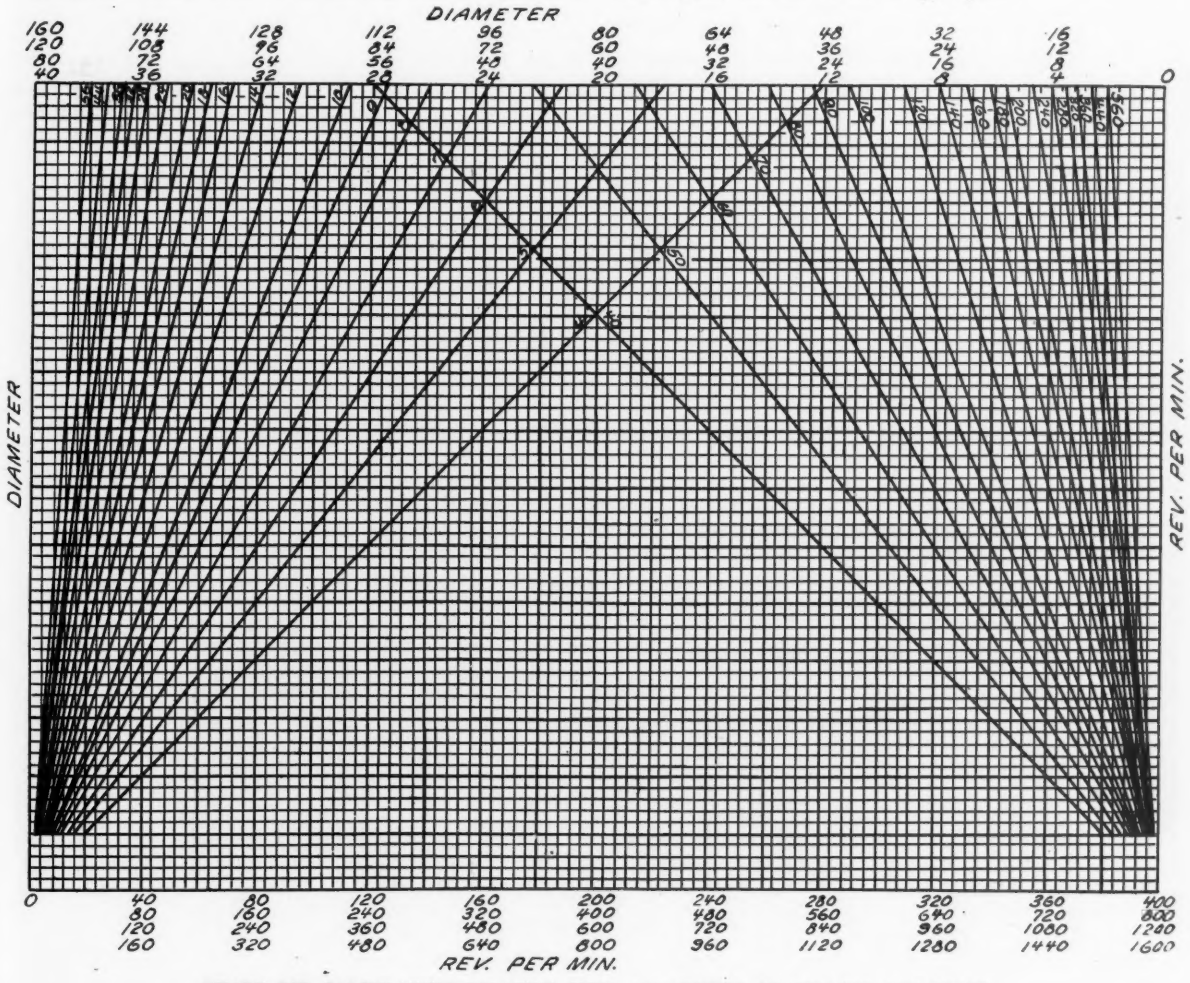


CHART FOR CALCULATING RELATIVE SIZES AND SPEEDS OF PULLEYS AND GEARS

JOHN CRAIG SCOTT, whose writings have been familiar to our readers for some time on subjects pertaining to steam and electrical engineering, has recently accepted a position as chief engineer and electrician with Jas. H. Matthews & Co., Inc., of Pittsburgh, Pa. This firm is building a large plant at a cost of $200,000 in the Oakland district, Pittsburgh, for the manufacture of rubber stamps, pencils, etc., and Mr. Scott will have supervision of all machinery and equipment, consisting of some 100 motors with necessary engine, boiler and dynamo equipment to supply the needed current. Among other units will be a 1200-ampere generator, of which the entire output is used for electroplating. Mr. Scott has now taken up his residence in Pittsburgh and has asked that Practical Engineer, to which he has been a subscriber a number of years, shall follow him to his new home in the "smoky city." His clear grasp of the principles and practice of engineering, as shown in his writings, is guarantee of success in the new field of endeavor.

ICE MAKING AND REFRIGERATING MACHINES

Points to be Looked After in Installation and Management to Secure Minimum of Attention and Maximum of Capacity and Efficiency

By William H. Biesley

FOUNDATIONS FOR THE REFRIGERATION machine, which must support both engine and compressor, should be made of concrete or brick. If of brick, they should be well grouted in, and finished with a good coat of cement mortar well troweled down. In setting the foundation bolts, they should be set in pipe, or better still, if they can be secured, use old boiler tubes of ample size; if the foundation is of brick, an opening may be left around each bolt, which will give a limited amount of play to the bolts and allow them to enter the base of the engine or compressor, in case the template is not true.

Care should be taken when placing foundation bolts that the nuts are securely fastened on the bottom end so there is no possible chance for them to unscrew from bolts. The better way is to have heads or keys placed on lower end of bolts, with cast-iron washers in which recesses have been cast to prevent them from turning.

In setting the template, blocks of wood or short pieces of pipe should be placed between each nut and template so as to keep each bolt the proper height above the foundation. After engine and compressors have been moved into place wooden wedges not less than 1 in. thick should be used to drive under the

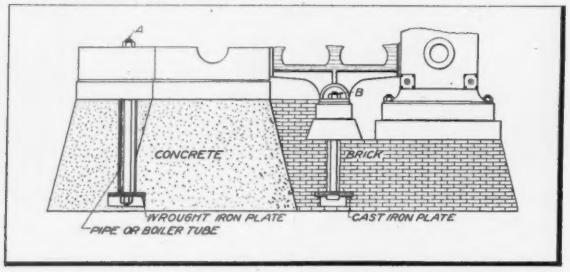


FIG. 1. FOUNDATION FOR COMPRESSOR, ILLUSTRATING METHODS OF INSERTING AND HOLDING BOLTS

engine and compressor frame to level up and also to allow sufficient space for grouting engine and compressor beds; if iron wedges should be use for this purpose, they should be removed after the grouting has set, and the holes filled up. Under no circumstances should they be left under the engines, as they would have a tendency to allow the bed to slide about should it become loose on the foundation. The greatest care should be exercised in filling up the space around foundation bolts with the same material that is used for grouting.

Lining Up and Cleaning

IN case of a self-contained machine, where engine and compressor are on the same bed plate, there is no need of lining up, as these parts are shipped from factory to shop in perfect alinement; this is usually accomplished by inserting dowel pins through engine and compressor frames into the bed plate, and in this condition it is impossible for them to become disarranged. But where the machine is of large proportion and the engine and compressor are parallel with each other, care must be taken in leveling and lining up both engine and compressor with the main shaft. Then both engine and compressor must be well grouted in, as any slight settling may throw them completely out of line, and thus cause pounding and heating of journals, resulting in excessive oil bills.

After engine and compressor are lined up too much care cannot be exercised in cleaning thoroughly all boxes, which should be done by washing them out well with kerosene oil. All bright work should be cleaned of the protective coating, and journals keyed up to a fair fit. All cylinders, valve chambers, and their several parts should be thoroughly cleaned before attempting to start up, as the least particle of any substance may cause a leaky valve or scored, and cut cylinder.

Placing the Condenser

THE condenser should have a good solid floor or foundation on which to rest, and it is essential that this foundation or floor should be perfectly level, or at least the condenser must be placed as near level as it is possible to get it. Any unevenness in the

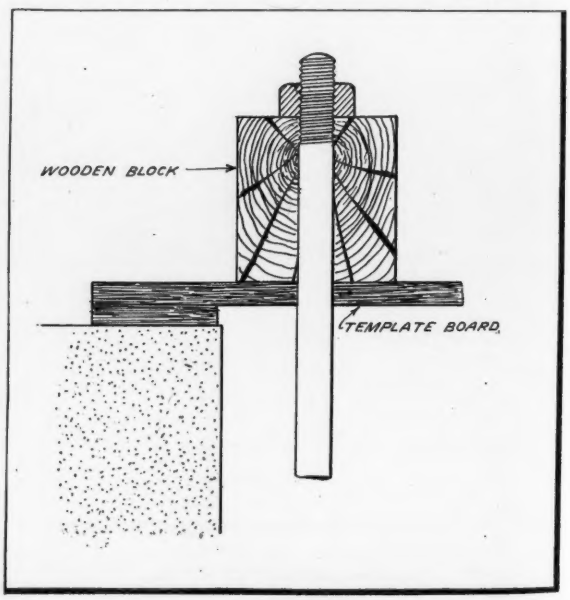


FIG. 2. HOLDING OF BOLT IN TEMPLATE TO INSURE RIGHT HEIGHT TO TAKE COMPRESSOR BASE

pipes or coils of the condenser will form traps and prevent an even flow of liquid ammonia to the receiver, thus interrupting the work of the condenser. Location of the ammonia condenser depends much upon local conditions, but it should not be placed higher than is absolutely necessary; as it is usually a costly proposition to pump water, and it is useless to pump the large weight of water which is necessary for the ammonia condenser any higher than can be avoided. If the condenser is of the atmospheric type, it is well

to place it only high enough so that the cooling water can flow to the steam condenser by gravity,—that is, in plants that may be producing ice or where the engines are run condensing and require the water for that purpose,—and should they be of the double pipe type, they should be placed only high enough to drain the ammonia to the receiver completely, as the water can be elevated after passing through the condensers to any desired height.

In the small machines that are used for refrigeration only (that is, from 1 to 5 tons capacity) the double pipe or submerged condenser is used, and often

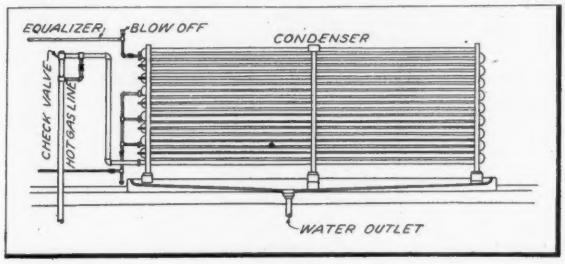


FIG. 3. CORRECT ARRANGEMENT OF CONDENSER CONNECTIONS

times water is used direct from city water mains; but in such cases a small cooling tower which can be built at slight expense will save about 90 per cent of the water otherwise required for this purpose. In small plants of this kind which are run by gas engines, the water from the condenser can be run through the jacket on the gas cylinder and then to the cooling tower.

Every condenser should have a valve on the gas inlet to each coil and one on the drain or liquid line from each coil, thus providing a means for cutting out any individual coil, if necessary. They should also have a purge valve on the highest point of the condenser, to provide a means of purging the condenser of any foul gases or air that may accumulate.

(To be Continued.)

ARCTIC DOUBLE-SINGLE ACTING AMMONIA COMPRESSOR

Special Features of Valve Arrangement and Construction; Jacketing Graduated to Secure Heat Economy

SINCE the appearance on the market of the Arctic Double-Single acting ammonia compressor, some years ago, engineering bodies and colleges having courses in refrigerating engineering have shown an increased interest in the machine, from year to year, hence the following description of this machine will no doubt be of value to our readers.

Referring to Fig. 1, it will be seen that the frame is of the horizontal, heavy-duty type of well balanced proportions. The heads of the cylinder are flat, reducing the clearance loss, and these cylinder heads, also the stuffing box are water jacketed. Crank and crosshead are of cast steel, with babbited shoes, providing for both top and bottom adjustment. The crosshead guides are of the bored type, with extra large pins, while the spindle steel piston rod is of heavy design.

Figure 2 gives a clear idea of the interior construction of this compressor, and of the suction valves, which are one of the important factors in making it possible for the Arctic Co. to guarantee high duty. The piston is shown in the position it assumes when compressing on the head end of the cylinder, while the piston valve on the crank end is open, allowing the low-pressure gas to enter the crank end of the cylinder.

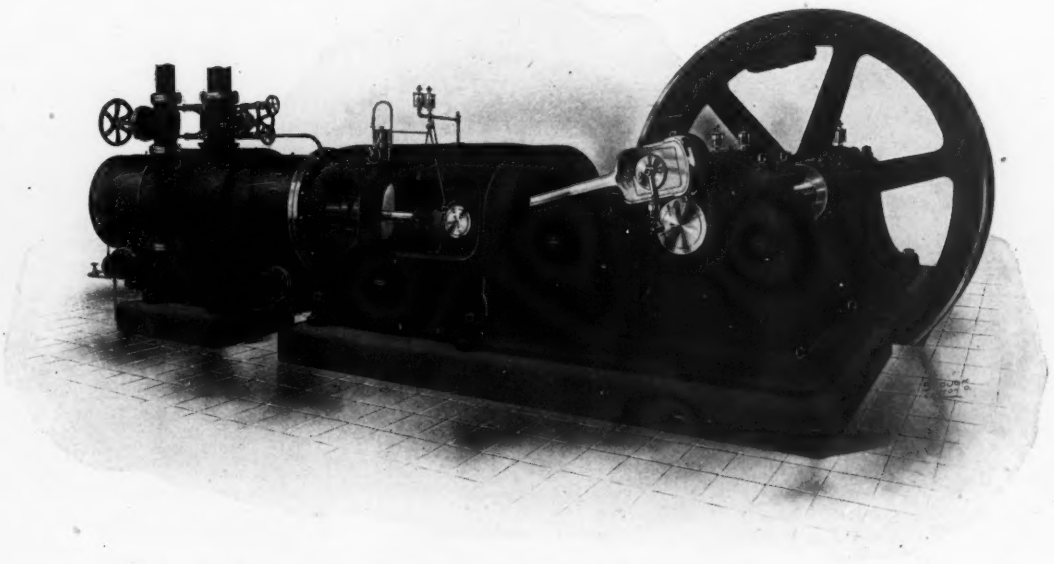


FIG. 1. EXTERIOR VIEW OF ARCTIC AMMONIA COMPRESSOR

Gas Compression

GAS enters the suction chamber through the diagonal ports at the center of the cylinder. As the piston reaches the head end of the cylinder and comes to a stop (while the crank is passing center) the piston shell on the crank end, due to its momentum, travels ahead until it comes in contact with the piston, thereby closing the suction opening between the suction chamber and the crank end of the cylinder. As the piston

pulls away from the head end, the gas remaining in the clearance space in the head end re-expands until the pressure is practically the same as exists in the suction chamber.

At this point the piston shell stops, while the piston travels toward the crank end, until it comes against the limit collar in the piston shell, at which point it carries the piston shell with it to the end of the stroke,

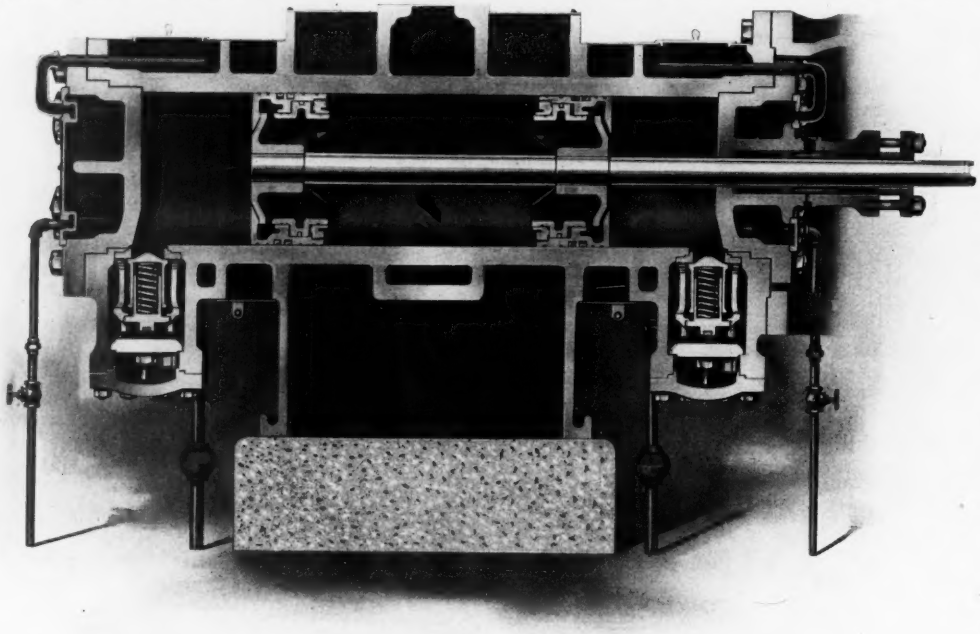


FIG. 2. INTERIOR VIEW, ARCTIC DOUBLE-SINGLE ACTING COMPRESSOR

allowing the gas to flow from the suction chamber into the cylinder. This design and arrangement of the suction and discharge valves in the Arctic compressor, make specially for safety.

Suction valves are springless and mechanically operated; a feature which, together with the large area of these valves, causes the suction gas to enter the compression chamber without decrease from suction pressure. From this explanation it will be readily understood why the Arctic machine will compress a great weight of gas per stroke, and it is the weight and not the volume of gas handled which governs the capacity of an ice machine.

Piston and Valve Details

FIGURE 3 shows the detached piston and valves. The piston rod carries 2 piston heads, each having a webbed and ported head, carrying a flange near one end. This head is machined to a diameter somewhat less than the bore of the cylinder. A piston shell bored to fit the piston head is finished on the outside to fit the cylinder bore and provided with packing rings, this shell being locked on the piston head by a split locking ring, to allow the shell a certain amount of travel independent of the piston head. In its entirety, this forms the piston and suction inlet valve. On this compressor, the Arctic Co. uses nothing but heat and oil treated chrome vanadium steel, for the discharge valve springs, which makes possible guarantee of long life on these parts.

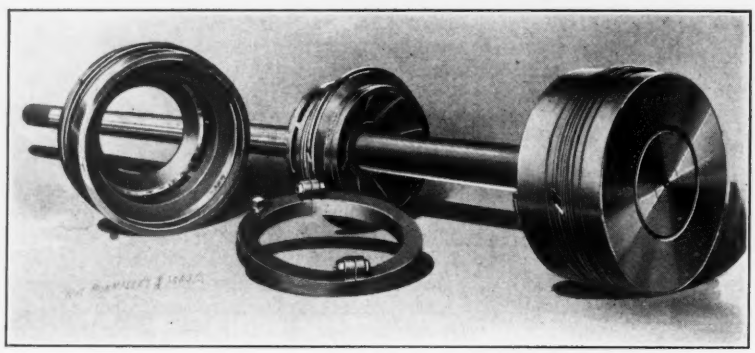


FIG. 3. PISTON AND VALVES OF ARCTIC COMPRESSOR

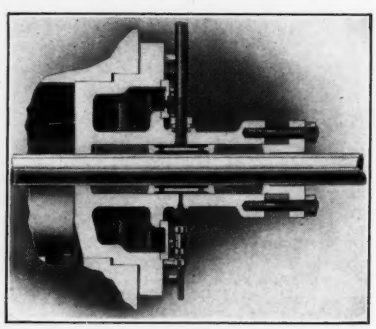


FIG. 4. INTERIOR OF COMPRESSOR STUFFING BOX

Discharge valves are located one at each end on the under side of the cylinder, a location which in case of flooding the compressor with liquid, allows perfect drainage by gravity, ahead of the piston. This relieves

the machine of the shock and strain of forcing the liquid out, and thereby eliminates the possibility of ruptured heads or cylinders, a feature especially valuable in the case of machines operating with wet or saturated gas. The discharge valve cage is held against a ground joint by a heavy set screw, carried on a steel bar, which in turn is supported on an internal flange projecting from the wall of the discharge chamber. The whole construction is entirely independent of the covering cap, and may be easily removed or replaced, if necessary.

Jacketing

THE method of water jacketing is another special feature. The extreme ends of the cylinder and the cylinder heads, which in all machines are subject to the greatest heat of compression, in the Arctic unit, are water jacketed; further, the central portion of the cylinder, where the temperature of the gas is lower than that of the water, is cork insulated; the next portion of the cylinder, coresponding to the first half of the compression stroke, being jacketed with confined air. That portion of the cylinder which is water jacketed, receives water from the heads at the bottom sprayed over the cylinder end by means of a slotted pipe, from which point it is drained to the sewer.

To inspect the interior of the compressor, it is only necessary to uncouple one water joint for the purpose of removing the front head; there are no ammonia pipe connections or manifolds to be disconnected.

This machine is built by the Arctic Ice Machine Co., at Canton, Ohio.

OILING SYSTEMS THAT PAY 100 PER CENT DIVIDENDS

Development From Hand Oiling Systems, Saving in Typical Plant

By Wm. L. Morris

ECONOMY that can be derived from the reuse of oil is so variable that there must of necessity be opponents to as well as advocates of its use. The great disparity in results obtained is not so much the variation in the journals to be lubricated as it is the methods employed to clarify and supply oil to the journals. Nearly all the manufacturers of oiling systems of today are using the same devices and arrangements that they employed while this system work was in its infancy, using the old hand supplied filters with a few minor modifications to serve as a part of an oiling system. Opposition is evidenced against the oiling systems of today which have not even at this date become more than an aggregation of hand outfits.

If the work done by the system is nothing more than would be done by hand, it is merely a substitution and as such it may not save a single per cent. The 100 per cent system must be vastly more. An engine which could be run with about a pint of oil an hour should have not twice nor three times as much from the system, but all it will take and not waste oil onto the floor. Generally this will be from 200 to 400 times what would be fed by hand. By being able to feed this large amount of oil, it is possible to reduce the friction of an engine 5 per cent.

An oiling system that will reduce friction 5 per cent will effect savings in one year sufficient to pay the entire cost of installation, and if run 24 hr. a day it will effect even more.

To secure the ultimate savings that are possible, it is necessary that the system be exceedingly large in all its provisions, and that it can be easily kept clean. It should be possible to clean all parts of the system while it is in service; men don't work overtime if they can get out of it, the result being that cleaning would be neglected. A 100 per cent system can not be obtained with less than 2 sq. ft. of filtering surface for each gallon of oil filtered per hour and the capacity should be not less than 200 times what would be possible with a minimum hand feed.

The per cent value of a system closely approximates the amount of surface furnished and as is common with all machinery, the price does not increase as much as indicated by the quantity. If an engine room be supplied with a small system having 10 sq. ft. of surface that should have 100, then there would be a constant yearly loss of 9/10 the value of the larger 100 per cent system. There are many plants now equipped with insufficient systems that much money can be made out of the investment in a system having the dimensions noted. A sample list of savings are here tabulated, using a sample plant as an illustration.

3, 500 kw. engines run 20 hr. per day; average full load, 12 hr.; 300 days per year. Coal consumption 10 lb. per kw.-hr. Coal cost per ton, $1.80. Unloading, firing, cleaning, ash, cleaning boilers, etc., $0.40 per ton.

Coal Cost per year:		
27000 tons @ $1.80	$48600.00	
Coal handling @ $0.40 per ton	10800.00	
	$59400.00	
5 per cent frictional saving		$2970.00
24 bbl. @ 50 gal. @ $0.40	$ 480.00	
6 bbl. with system @ 50 gal. @ $0.15	45.00	
Oil saving		$ 435.00
Repairs to journals	$ 100.00	
Repairs with system 20 per cent.	20.00	
Savings in repairs		$ 80.00
Shut downs, loss of labor, materials and profit		$ 75.00
Value of engines, etc., that would be lost when worn out—$100.000.00, life by hand feed 25 yr.=$4,000.00 per year depreciation:—life by stream feed 40 yr., or per year	$ 2500.00	
Yearly saving in depreciation		$1500.00
20 per cent of the time of oilers utilized for useful work, $1200.00 by 20 per cent		$ 240.00
Savings occasioned by removing vibration to foundations, piping, etc.—This saving disregarded. Total savings		$5300.00
Cost of system to effect these economies, including necessary oil guards, cups, piping and installation		$2675.00

The figures as given show a 200 per cent system, this being possible if plant runs as many hours as noted and other conditions being as shown. It is only in plants using refuse for fuel or other exceptional conditions that would not permit a 100 per cent saving if provided with a 100 per cent system.

LETTERS DIRECT FROM THE PLANT

Cash Paid For Ideas Accepted. Sketches Desirable.
We Make The Drawings

HIGH STEAM LINE ON CRANK END

ON most engines the crank end card shows a higher initial pressure than the head end. Indicator diagrams have been published which have shown perfect conditions as regards valve setting and yet the only trouble that worried the engineer was that one end showed a higher initial pressure than the other. Nor was this defect confined to a particular type. It is

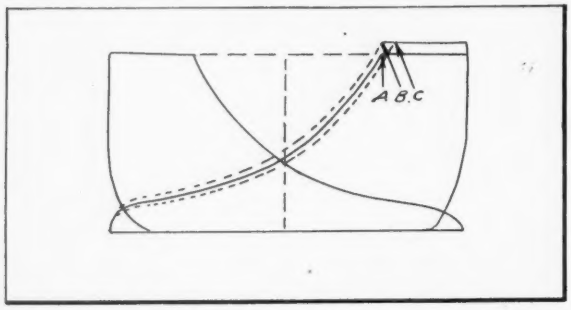


FIG. 1. CARD SHOWING ADMISSION PRESSURE HIGHER ON CRANK END

rarely that an engineer need fail to distinguish the crank end from the head end, if he is familiar with the underlying principles, because it is an established fact that with engines having a direct valve motion, in which the eccentric does not follow the crank but leads it, the crank end will measure the higher, while with indirect valve motion such as piston valves taking steam in the center and exhausting over the ends, if no reversing rocker arm is used it follows the crank.

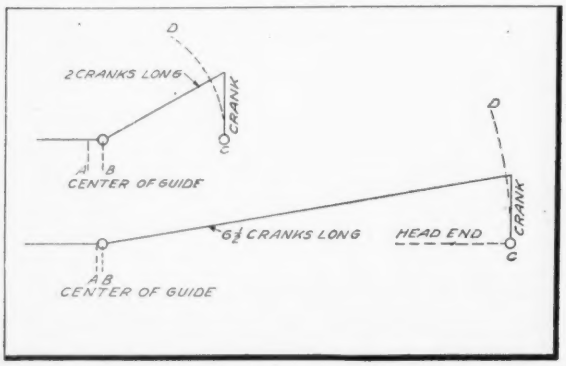


FIG. 2. EFFECTS OF ANGULARITY WITH LONG AND SHORT CONNECTING RODS

The defect though not entirly obliterated, is greatly improved except where the connecting rod is very short compared with the length of the crank, which causes the angular effect of the connecting rod to be more in evidence, as shown by Fig. 2. The angularity of the connecting rod is the cause of the piston moving more slowly on leaving and approaching the crank end, and traveling faster on leaving and approaching the head end. It is this slow movement on the crank end which enables the pressure to assume a higher plane because it surely takes time to attain boiler pressure. We also have the area of the piston which takes up so much room, making less space to fill and more time to fill it because of the slow movement of the piston.

An eccentric is really a crank and is subject to distortional movements the same as the connecting rod, only in a less degree. The action of the eccentric causes the valves to move very irregularly, as the crank does the piston. When the head end is taking steam the valves are moving very slowly, while on the other end the conditions are reversed. With the piston starting on the crank end and the eccentric moving on its head end with great rapidity, is another reason for getting so high an initial pressure in the crank end, because when the piston moves fastest the valves move the slowest.

If there is a reversing rocker arm between the eccentric and valve, the angularity as affecting the height of the diagram, practically equalizes the initial pressure on both ends, causing a fast-moving valve

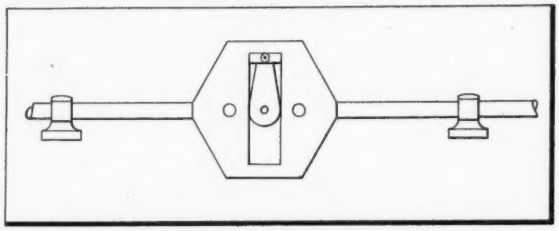


FIG. 3. THE SCOTCH YOKE

when the piston moves fast and a slow-moving valve when the piston moves slowly. Figure 2 shows how the angular effect increases as the connecting rod decreases in proportion to the length of the crank. Suppose we place the crosshead in the center of its travel, which would be at A and use the rule of making the connecting rod the length of A to C. If we place the crank on the half stroke, or 90 degrees from the head end, and try to connect the rod to the crank pin it will follow the arc D and be too short, necessitating advancing the cross head from A to B to meet the crank pin. Hence, while the crank turns half a stroke the crosshead has to move more than half a stroke as shown by the distance A to B, consequently the crosshead has to travel a longer distance from the head end for the crank to make ¼ a revolution than for the crank to complete the half revolution. This is why it travels faster in the first part, or from the head end, as the crank turns at the same speed all the time. The angular effect is increased as shown above in Fig. 2, by decreasing the length of the connecting rod.

There is a type of connecting rod and crosshead combined called the Scotch Yoke, Fig. 3, which would remedy the angular effect as far as the piston travel is concerned, but where the valve is operated by an eccentric we would get the slight effect due to the eccentric-rod angularity.

In Fig. 1 the full line A represents ideal conditions because of equal cutoffs, equal areas and equal heights on both the head and crank ends. I often wonder how others get them, because in measuring numerous diagrams from a large number of engines, having different valve gears, with speeds ranging from 50 to 300 revolutions, I have invariably found from 1 to 5 lb. higher pressure on the crank ends except where the remedies mentioned have been applied. If through ignorance of these defects we try to get equal cutoffs we will get the line B, Fig. 1, which, with the increased height and full expansion line, is sure to produce a greater area for the crank end and since we have the area of the piston rod, which decreases the square inch at this end, the effective work on each end is practically balanced because the higher initial pressure makes up for the loss in piston rod area. Hence, the absurdity of the common practice of subtracting the area of the piston rod in computing the theoretical horsepower of the engine. From Fig. 1 it is apparent that equal cutoffs and equal areas and equal steam lines to the point of cutoff rarely exists in actual practice. It is true that the expansion line may depart from the theoretical expansion curve, either above it due to leaking steam valves or below it due to leaking piston or exhaust valves or excessive condensation may to a certain extent make up the unequal areas.

If we hope to get equal diagram areas we must cut off sooner to make up for the higher initial pressure as shown at C, Fig. 1, and this would unbalance the work done by each end to that due to the piston-rod area. So we arrive at the conclusion that it is not a bad feature to have a higher initial pressure on the crank end as the piston rod takes up piston area (which is not the case on the opposite side of the piston) allowing the head end to do as much on less initial pressure, if the angular effect of increasing the height of the crank end is not too great. A. C. Waldron.

REPAIRING SMOKESTACKS

I HAVE had to repair 2 of our stacks by piecing them; these stacks passed through the center of the boiler house, which is 45 ft. high, and the roof has a steep pitch which made it hard to work upon. The side of another building was within 10 ft. of one stack and we made use of it, as in Fig. 1, by cutting a hole in the side for a 6 by 6-in. stick, which we ran out at an angle, with a brace from the ceiling to keep it in place. An eyebolt was put on the end with a nut and washer, and 2 blocks were hooked into the eye, one a 3-sheave block for doing the heavy work, and the other a 2-sheave to hold with while shifting. After getting the stack, which was 45 ft. high, and weighed 2100 lb., in as near a vertical position as possible, a horse pulled it clear of the roof where we made it fast to shift the tackle, and then raised it so that it could be swung into place on the old stack, upon which a ring 1 by ⅜-in. had been placed to hold the new piece.

With the other stack we could not use that method, as the building was too far away, and the stack set in 15 ft. from the edge of the roof, so a straight hoist could not be used either. Not having anything for a gin pole, we made one by using 3 lengths of 3-in. pipe and at the top put a coupling into which was screwed a plug with an eye bolt for attaching the guide ropes. A large flange was used on the bottom for a rest. Near the top an eye bolt fastened with a nut held the block used to hoist the boom, also the block used to raise the ring to which the boom fastened, up the gin pole and allow it to have a long swing across the roof.

The boom was made of 3-in. pipe with an eye in each end for a bolt, one to hold the gin pole ring and the other the block and hook that raised the stack. In this case the boom and stack were drawn up straight with the gin pole as far as possible, then the

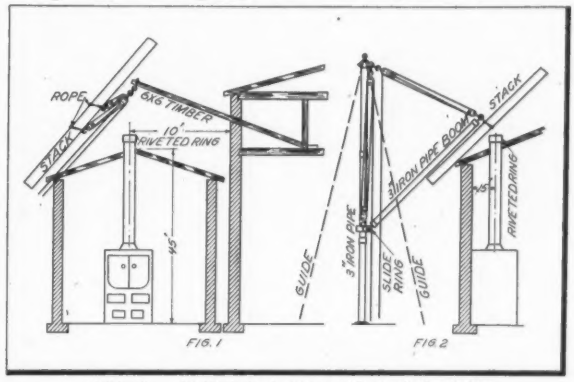


FIG. 1. RAISING STACK NEAR BUILDING
FIG. 2. RAISING STACK WITH GIN POLE AND BOOM

boom was let out while the lower end of the stack was drawn into place and secured with guy ropes. If the stack is near enough to the edge of the roof and not too heavy, a straight pole a little more than half the length would be enough. Where the stack is very heavy and long 2 poles are used, one on each side, as this gives a better chance to hoist and change the position of the rope on the stack, one being used to hold while the other is being shifted.

D. F. Crowther.

THE TURBINE INDISPOSED

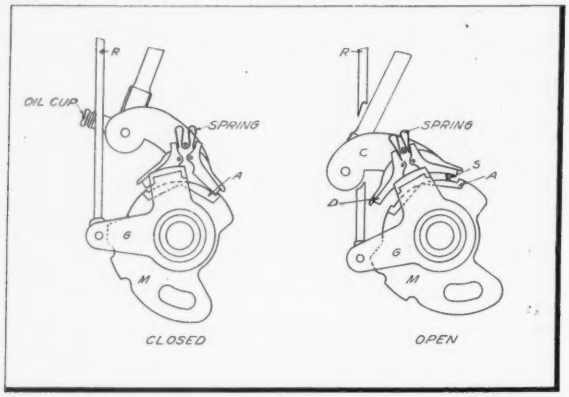
THE night engineer of our plant reported that one of the 500-kw. vertical turbines vibrated so badly that it had to be shut down, he attributed the trouble to the guide bearing. A superficial inspection revealed nothing abnormal. Turbine up to speed and on line with 500 to 700 kw. ran smoothly, no indication of trouble.

The following morning the turbine was again found shut down. This time it had run away and tripped itself, it was said that it carried the load for a long time after tripping (shutting steam off) and played a tune the like of which had never before been heard.

We inferred that something unusual must have happened to the emergency governor, since its last try out a few weeks before, when it tripped between 6 and 10 per cent high. Accordingly we tried out the emergency governor and found it would not trip, it was with difficulty that the springs could be pried away from the stops; in normal position they can be pulled off the stops with the fingers. These springs had to be slacked back ⅛ in. before they tripped at the predetermined speed. That they did work at all and prevent a wreck with possible loss of life is something for which we have reason to be thankful.

There is no record of any one attempting to adjust or alter them in any way and as the tension of these springs lessens with time and use we are at a loss to account for this strange condition.

After resetting the emergency governor and having found no cause for turbine's running away, tools were picked up preparatory to leaving when a machine screw was noticed lying on the steam chest. The cause of the turbine's running away was now solved. This screw, whose function is to fasten the steel block to the cam, backed out and prevented the dog from dropping on the cam and closing the valve, or got jammed in such a way as to render the governor inoperative.



DETAIL OF GOVERNOR WHICH CAUSED TROUBLE

The accompanying sketches show the valve in closed and open positions. In the view of the open position, S shows the the screw that prevented the valve from operating. The position of the shield plate A is determined by the governor and receives its motion through rod R. The dogs, D, are part of the bell crank C and reciprocate with it. Cams M are loose on the bell crank shaft and move only when position of A is such as to allow the dogs to drop into the shoe A.

A. B. C.

THE BACK PRESSURE LINE

I HAVE discussed the subject of the back pressure or exhaust line of a conventional indicator diagram with some of the best engineers in our city but it seems as if no 2 have the same idea as to its form.

My theory is that the back pressure line does not run parallel with the atmospheric line but curves away from it for the reason explained here in.

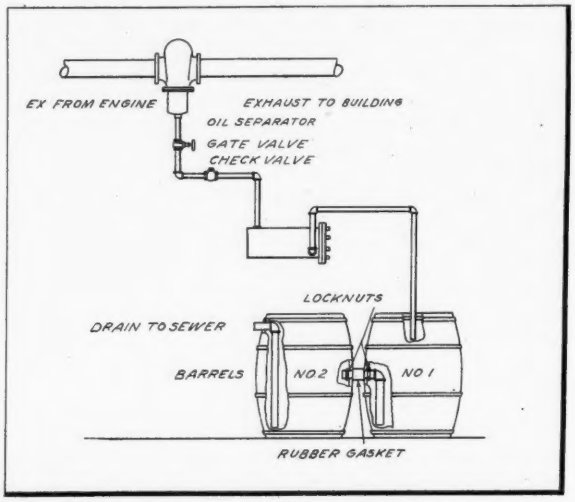
In a conventional diagram it is shown that the steam is expanded to nearly atmospheric pressure, this being done there is no excessive out rush of steam when the exhaust valve opens. The piston velocity is higher than the expanded steam, therefore the steam is pushed from the cylinder by the piston, this compresses the steam to a certain extent due to the resistance to flow through the port and passages. When the center of the stroke is reached, the piston has increased to its highest velocity and the out pouring steam offers its greatest resistance at this point. This variation is slight on a high pressure diagram and could scarcely be detected only by very accurate measurement.

If it were possible to take a diagram during the exhaust only, using an 8 or 10 lb. spring I am sure the back pressure line would show a difference in pressure at various parts of the stroke. As I have stated previously this would be due to the varying velocity of the piston causing a rising and later a falling in pressure.

I would like to have some readers express themselves on this subject. J. W. Dickson.

OIL TRAP AND SEPARATOR

CYLINDER oil was giving trouble in the sewer from the station, almost closing it. To prevent this I constructed a separator with 2 barrels. I found 2 ½-size meat barrels, knocked out the bung-hole plugs, connected them with a close 2-in. nipple, with a thick rubber gasket between barrels, and lock nut on each end of nipple. I screwed an ell on the end of the nipple



ARRANGEMENT TO KEEP CYLINDER OIL OUT OF SEWER

in barrel No. 1, also apiece of pipe extending to the bottom of the barrel. This operation was repeated to form a drain from barrel No. 2.

The idea was to keep the hot water always on top. The trap discharges into No. 1; the cold water in the bottom goes into No. 2. If there is oil in there it comes to the top and the water settles to the bottom, coming up and going out the drain. I save ½ the cylinder oil, and have no more sewer troubles. This is better than a surge tank, because the vapor will escape. The trap holds back the steam pressure and the check-valve keeps the vacuum pump from drawing the water and oil back into the heating system when pumping down or when steam is first shut off. W. S. H.

BOILER REGULATIONS

IN your issue of April 15th you publish abstract and discussion of the report of the Committee of the American Boiler Manufacturers' Association, which refers particularly to Massachusetts rules and regulations. The Ohio rules, which go into effect on July 1st, are identical, and so are the rules of the city of Detroit, except that Detroit does not require shop inspection, and all boilers are subject to their local inspection. In the case of Massachusetts and Ohio there has to be a preliminary inspection, as well as a final inspection, making 2 trips for a boiler inspector, the expense of which either has to be borne by the manufacturer or the purchaser.

We do not see why the preliminary inspection might not be done away with, as that was the original Massachusetts provision, and they could certainly take the affidavit of the manufacturer in lieu of this preliminary inspection, because certainly no reputable concern would make an affidavit which would set forth facts that were not true. We then have Philadelphia regulations, Chicago, St. Louis, Seattle, etc. In Ohio they have exempted portable boilers used in pumping, heating, steaming and drilling in the open field, for

water, gas and oil, and portable boilers used for agricultural purposes, and in construction of and repairs to public roads, railroads and bridges, etc.

If a manufacturer of hoisting engines wishes to carry a stock of boilers, so that he can make prompt deliveries, the only safe course for him is to have the boilers built on the Massachusetts standard, and when inspected have them stamped Mass., with the serial number, and Ohio, with the serial number, and they will then be accepted anywhere in the United States; but to meet Chicago requirements, they will have also to be made with hollow staybolts.

There is no telling how many additional standards will be issued in the course of the next 12 months, and it is going to make confusion worse confounded. Of course it would not be possible for Congress to pass a law which would take away from the different states their right to regulate their own internal affairs, but if Congress would appoint a Commission to draft a form of specifications to be known as the United States standard, and make it optional, not obligatory, it would not be long before public sentiment would compel the adoption of this standard. We believe that a move in this direction would have the hearty support of all manufacturers, as well as users. It is absolutely impossible to secure concurrent legislation between the states.

Phoenix Iron Works Co.,
John Dick.
Vice Pres. and Gen. Mgr.

CARD COMMENT

IN the March 1 issue of Practical Engineer, A. E. B. shows a card from his 50-yr. old slide valve engine, 12¾ by 42 in., and asks what changes might be made to obtain a better card.

To begin with he has an extra long stroke of the piston, 42 in., and the piston about 4 in. thick makes his cylinder about 46 in. long. By using a 3-way

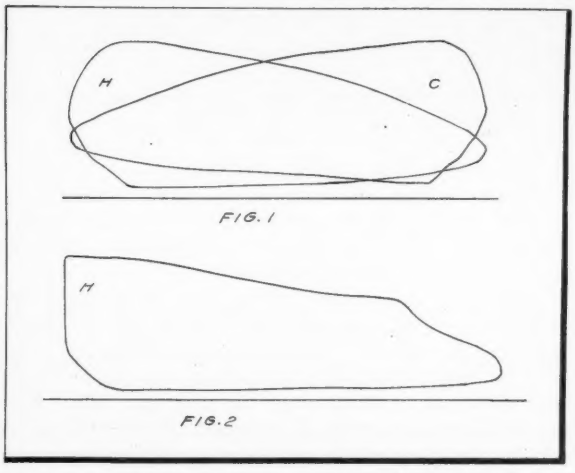


FIG. 1. CARDS TAKEN WITH 3-WAY COCK IN INDICATOR PIPING

FIG. 2. CARD TAKEN WITH SHORT INDICATOR PIPING

cock in the center of his indicator piping he has 23 in. between the 3-way cock and the end of cylinder to say nothing of the elbow and nipple; if he will connect his indicator close up to the end of the cylinder he would obtain a far different card. I enclose a "before and after" card taken from a slide valve engine to prove my assertion.

N. W. Duell.

A LOCOMOTIVE EXPLOSION

THE penalty for neglect was severe in the recent case of a locomotive explosion near Roseburg, Ore. The explosion, which resulted fatally for the engineer and fireman, was due to a shortage of water in the boiler, causing the crown sheet to drop into the fire box.

FIG. 1. THE DEMOLISHED LOCOMOTIVE BOILER AND FIREBOX

The boiler was blown about 200 ft. and landed in the position shown. The crown sheet was blown out entirely and all that remained of the left side of the fire box was

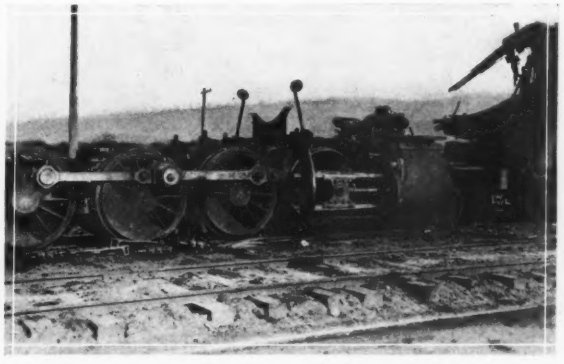


FIG. 2. TRUCKS OF LOCOMOTIVE WHICH EXPLODED

a piece about 5 in. wide, on the corner next to the flue sheet; the back was torn loose and hung about 15 in. away from the stay bolts and braces, while the right side was torn away about 12 in. from the top.

The engine trucks remained on the track and were practically unharmed.

John P. Durfee.

SETTING ECCENTRIC WITHOUT REMOVING STEAM CHEST COVER

ON page 433 of the April 15th issue, G. A. W. wishes to know how to set an eccentric which had slipped, without removing the steam chest cover. The way I would proceed would be to make sure the steam supply valve was closed, then get the engine on exact dead center, put the eccentric 90 deg. ahead of the crank, that is assuming it runs over. Then open the drip cock or indicator cock if there is one on the end where the piston is, in either case have the valve which you use in such a position that you can see if any steam comes from it. Next, open the supply valve just a little, then move the eccentric ahead the amount of lap and lead when steam should issue from the drip cock, or indicator cock, which

ever is used. Turn the engine to the opposite dead center and if steam issues from the opposite end the valve is set good enough for a temporary period.

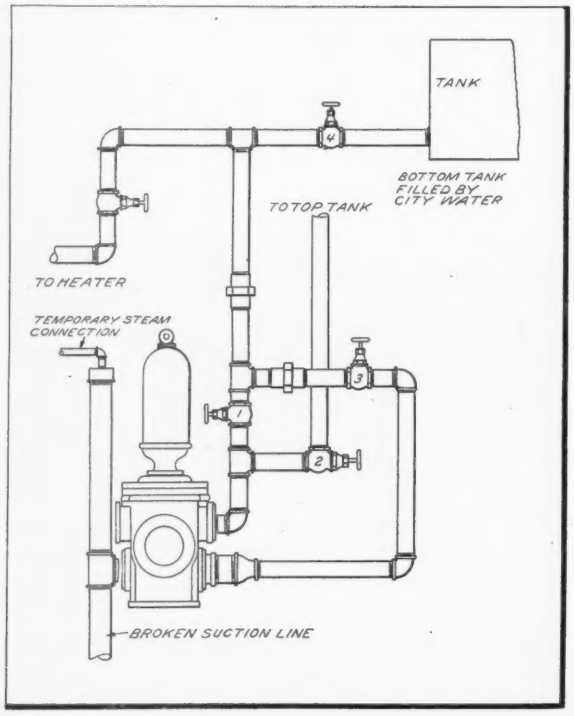
The steam must be shut off at all times when turning the engine over by hand or power. If the steam valve was set so that steam issued from the cocks at one end it is almost sure to issue from the other end unless you moved the eccentric too much.

John Mitchell.

SUPPLYING WATER IN FACTORY

THE enclosed sketch is of a pump at my plant showing the water end and pipe arrangement to supply water to a tank on the top of our factory. As you will see the suction pipe is disconnected on account of its being crushed in by the heavy weight of 2 large cement walls which ran across the path of suction pipe completely cutting off water supply. So we use city water for boiler, lavatories, etc., the supply being through ¾-in. pipe.

During the severely cold weather we have just experienced we could not get water up to the top tank;



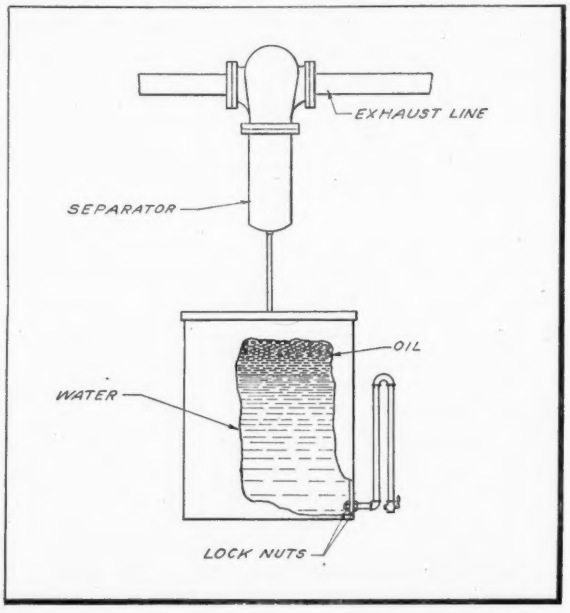
EMERGENCY PUMP PIPING

it would only lift about 12 ft. from the meter; so I put a pipe close to the meter, filled the bottom tank (as per sketch), made the arrangement to pump as shown and pumped water by this means to the top tank, thus saving a shut-down and choked sewer pipes. The watchman fills the bottom tank during the night and from this I fill the top tank during the day, twice a week. This is done by closing valve No. 1, and opening valves Nos. 2 and 3, valve No. 4 is kept open all the time.

As the suction pipe gave way in the fall we decided to use city water till spring, then sink an independent well of our own. R. Mason.

REUSING OIL; LEAKING ENGINE VALVE

IN reply to B. A. T. in March 15th number, page 329, I will say that I have used the cylinder oil from a separator for some time and find it better than new oil. I have tested it on the piston rod and find that it sticks to the rod for hours, where new oil disappears in half the time. I am separating the oil from the engine cylinder and using it a second time in the lubricators of 2 pumps. The lubricators give no trouble and the pumps are well lubricated, they exhaust to the atmosphere. The oil is heavier than new oil, but I use the same amount. I have made a saving of 50 per cent on the oil bill. I use a common dipper with a small hole in the bottom to drain the water for skimming the oil off the separator. The sketch will explain itself as to tank and fittings. If no oil separator is installed in the exhaust line a tee may be put



PIPING TO SAVE CYLINDER OIL FROM EXHAUST

in place of an ell with a short nipple and drain pointed downward which will catch the oil. The water may be used for other purposes, or run to the sewer. The discharge pipe should be 1 in. and connected to the tank with 2 lock nuts and a little packing.

Regarding his engine, it appears that the piston rings, leak, or when admitting steam for test the valves may not be seated or may be clamped on the valve rod by screwing the nuts up tight. The valve should have at least 1/32 in. play between the nuts. The flywheel should be blocked when testing for leaks, which would permit enough steam to seat the valve. Regarding the engine backing up, this would happen with any engine of this type that cuts off short or the steam is cut off the head end and a slight leak would fill the smaller space in the cylinder first and back up the engine until it admits a little steam and rocks between admission and compression.. If B. A. T. could produce a few more indicator cards he could be given better light on the subject.

Piston valves, like all others, are not tight when they blow steam. Geo. H. Worth.

Successful Kinks From The Plant

For Saving Time, Work and Trouble

Tightening a Blower Fan Hub

A LARGE blower fan hub in a planing mill had become pretty shaky, all the rivets were loose and both spiders were so badly worn that they did not fit the shaft by a ½ in. As the hub was filled with babbitt this metal did not stand the pounding. The shaft being 16 ft. long and 5 in. diameter, experts had declared that the spiders must be rebored and a new shaft put in. The fan could not be spared from service long enough for that repair, and besides it was too much of an undertaking. Therefore, the plan I have illustrated by the accompanying drawings was adopted at my suggestion.

Two taper brass sleeves were made for wedges,

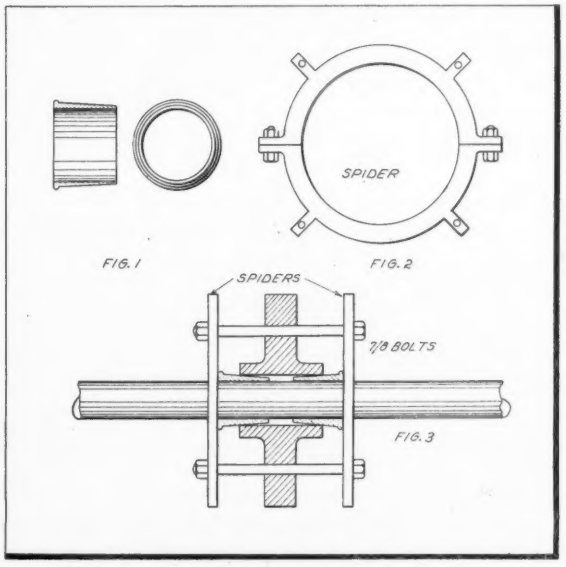


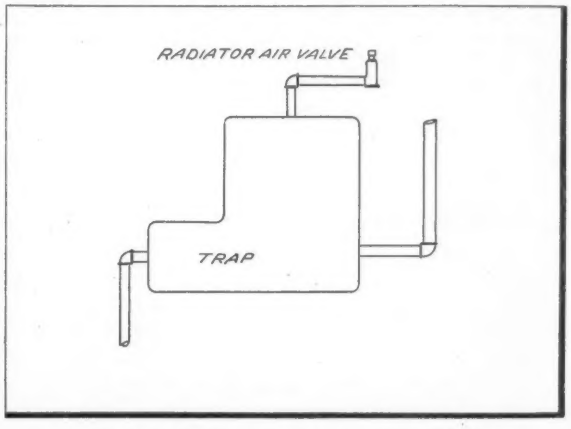
FIG. 1. VIEWS OF TAPER BRASS SLEEVES
FIG. 2. CAST-IRON SPIDER
FIG. 3. SECTION OF THE FINISHED REPAIR

the inside diameter being made to fit over shaft, each with a flange on the thick end as shown in Fig. 1. The sleeves were turned as one piece and cut in two. Then 2 cast-iron spiders were constructed in 4 sections and the 2 halves were then bolted together, as shown in Fig. 2. These spiders were bored to fit loosely on the 5-in. shaft.

After slipping the cone brass sleeves under the hub of the fan as in Fig. 3, the cast-iron spiders were put on the 5-in. shaft one on each side and 4 ⅞-in. tie rods were passed through the holes in the spider arms and between the arms of the fan. Tightening on the rods drew up the spiders and wedged the sleeves solidly in place under the fan hub without throwing the fan out of center or balance, or interfering with its running speed, except to cause a 4-hour shut down while adjusting the various parts. The repair tightened everything up nicely and the fan has been running in first class shape for the last year. The expense was only $8.60 and the labor of about 15 hr., and saved the price of a new 5⅞-in. shaft 16 ft. long, the labor of babbitting 4 large pillow boxes and lining the shaft up again. The fan is 9 ft. diameter and 24 in. wide, with a cast-iron housing. J. A. L.

Air Out of Trap

THE arrangement shown here for the installing of a steam trap, is a good one for lines where you wish to keep the pressure down to a minimum. It consists simply of having an air vent valve, an old radiator valve will work, to keep all air out of the line. I have



TRAP SHOWING AIR VALVE CONNECTION

used this on lines in connection with refrigerating systems and the action of the valve will work off the air and keep the line from binding and drain it of water as well. In fact the trap will do much better work when provided with a valve in this manner.

C. R. McGahey.

Using Brass Polish

IF any of the ordinary liquid polishes is used for brass polishing, a single can may be made to do the work of several cans by adding gasoline when the liquid gets low in the can. As the liquid is used up a lot of sediment will settle in the bottom of the can, and when the extra gasoline is added this sediment should be stirred up with a stick. A small amount of water may be added with the gasoline, if desired. The time that the polish takes to dry on the brass can be regulated by varying the amount of water added, with the gasoline. The more water, the slower the polish will dry.

If a piece of woolen cloth is kept for polishing the brass, it will soon become filled with the polishing powder, and then a very thin gasoline solution containing only a small quantity of the polishing powder, will do for wetting the polishing cloth.

H. M. Nichols.

Questions Answered and For Answer

Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp

Setting Valves of an Erie City 4-Valve Engine

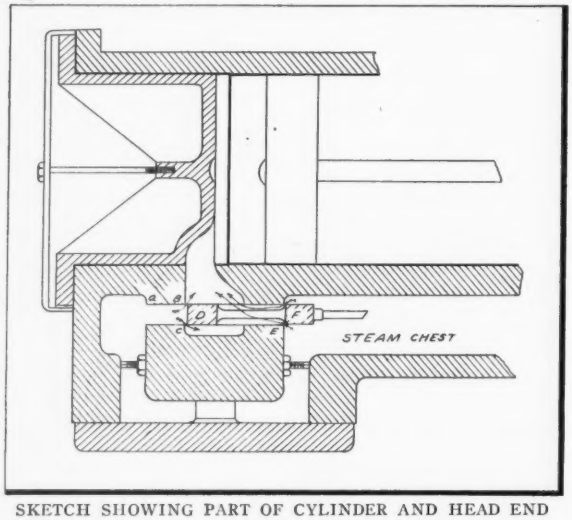
SHOULD be glad if you will illustrate and explain the valve mechanism of an Erie City 4-valve engine with shaft. Further please give directions for setting the steam and exhaust valves and state if the steam valves are double ported, also if there is an exact location for the pressure plate that the steam valves work under.

Will it affect the distribution of steam if the pressure plate is removed too far endwise in either direction?

I am operating two Erie engines and on light loads they will race. As near as I can measure there is about 2/1000 in. clearance between the steam valves and the pressure plate.

In the evening when I throw the load off to shut down, the engines always race but in the morning when starting they do not race. V. H.

A. The construction of the Erie City 4-valve engine is such that the action and performance of the steam valves is entirely separate from the exhaust valves as each set is operated by its own eccentric.



SKETCH SHOWING PART OF CYLINDER AND HEAD END STEAM PORT AND VALVE OF ERIE CITY 4-VALVE ENGINE

We will take up the exhaust valves first. First, set the wrist plate central by the travel marks and fasten it solidly in this position by inserting a piece of cardboard under the collar and drawing down gently on the screw. Then adjust the exhaust valves for the amount of lap which you wish to give them, which varies from 1/16 in. to line and line. Later, by means of the indicator, you can check up and make any slight changes that may be found necessary.

Plumb the carrier arm by means of the rod connecting it to the wrist plate, taking care that the eccentric is loose on the shaft, after which adjust the eccentric rod so that the wrist plate will travel equally on each side of the center mark when the eccentric is in the extreme position.

If the engine runs over, place it below the back center with the crosshead at a distance from the end of the stroke that you wish for compression which varies from 5 per cent to 12 per cent of the stroke, depending on the speed, steam pressure, etc. Then move the eccentric around the shaft until the exhaust valve at that end has just closed, and fasten it temporarily. Check up the work on the other end and if the results are close fasten the eccentric permanently.

Now for the steam valves. In view of the fact that the eccentric which operates the steam valves is attached to the flywheel (or to a separate governor wheel), and that this wheel is keyed to the shaft in a predetermined position, all adjustment must be made on the valve itself and the rods connecting it to the eccentric.

Remove the chest covers and the balance plates back of each steam valve. Then, referring to the accompanying sketch, adjust the valve stem or eccentric rod so that when the engine is revolved, the end "D" of both valves will travel the same distance past the edge "B" towards "a."

If this work has been done carefully, the amount of lead at "BD" on both ends of the cylinder should be the same. By means of a pipe jack, or other convenient means, block the weight end of the governor bar out to its extreme position against the stop pin. This is the position of least valve travel and corresponds to friction load. However, as you say that your engine runs away as soon as you throw the load off, one of two things is at fault: either the stop pin is so long that the governor cannot get a short enough valve travel to control the speed at friction load, or else the balance plate is not set square with the ports in the cylinder, which we will dwell upon later.

If it is the first trouble, carefully loosen the locknut on the adjustable stop pin attached to the weight arm and screw the stop pin in until the valve does not have any lead when the engine is revolved by hand, meanwhile keeping the weight arm snug up against the stop.

Now if you do not get the balance plate on square, or move it to either side it will provide admission of steam past the balance plate, as at "EF" even when the valve travel is as short as possible, or so short that the valve does not open the port at all at the point "BD", so you can readily see that the balance plate must be square with the corresponding edges of the main ports so that the valve will open at "CD" and "BD" at the same instant.

The reason that the engines run away when the load is thrown off at night, and not in the morning when starting up, is because that in the morning the engine is cold or comparatively so, and thus the friction load is greater which takes up all the steam allowed to get by the valves from whatever cause.

For small and medium sized engines a difference of .002 inches is ample between the valve and the balance plate. G. H. Wallace.

Disposal of Sawdust and Shavings

I HAVE a problem concerning the disposal of sawdust and shavings from a planing mill at our shops here, which I would be pleased to have you or some of the readers of Practical Engineer to solve.

At present they are conducted from the cyclone on the roof, through a 12-inch duct to the furnace of one of the stationary boilers. As the output of the mill is very unsteady, we have at times too hot a fire under the boiler and the balance of the time a big volume of cold air blowing on to the top of the fire, reducing the efficiency of the furnace considerably.

Mechanical stokers and lack of storage space preclude the possibility of scoop-shovel feeding. I would like some suggestions for feeding these shavings and at the same time excluding the air. Even if the cyclone is in perfect condition, the draft will suck air through the shaving feed pipe. R. W. E.

A. It seems to me that this man is undoubtedly forcing his shavings into the fire place by back pressure in his cyclones instead of by the use of a spiral on the taper part of his cone which would force the shavings down by the velocity which they have.

It would be much easier to deposit these in the proper part of the fire box with the side feed which he uses rather than the usual form of firing at the front, and I believe that if he puts his cyclone in condition to have absolutely no back pressure with the spiral, it will be satisfactory to him. H . P. G.

Capacity of Ice Tank

WE have a 20-ton ice tank. How many tons of ice can be made if the process is crowded under proper conditions?

A. A 20-ton tank if properly installed, and well insulated, and freezing ice at a temperature of 14 deg. may be increased about 10 per cent, providing you can lower your temperature to about 10 deg. The time required to freeze a 11 by 22 by 32-in. block of ice at a temperature of 14 deg. is from 48 to 52 hr. This of course, depends a great deal upon the circulation that is maintained in the tank. By lowering the temperature to 10 deg. the time required will be about 42 hr.

Should you desire you might increase the capacity of your tank about 20 per cent by installing the flooded system. W. H. Beisley.

Boiler Questions

WHAT horsepower boiler would you use for the following sized engines:

1. High-speed engine, automatic cutoff, 100 hp?
2. Corliss, 125 hp.?
3. Plain slide-valve throttling engine, 100 hp.?
4. Compound Corliss type, 200 hp.?

2. If the area of a safety valve is 6 in. and distance from center of stem to fulcrum is 3 in., the valve weighing 4 lb., and the lever ⅜ by 1½ in. and 36 in. long, find the pressure to lift a cast ball 6 in. diameter that has a hole in the center ½ by 2 in. and set 30 in. from the fulcrum to center of ball.

3. Is it desirable to have a girth seam over the bridge wall? R. B.

A. For a 100-hp. automatic high-speed engine the steam consumption would be approximately 30 lb. of steam per horsepower hour, or 3000 lb. per hour. As a boiler gives approximately 30 lb. of steam per boiler horsepower at normal rating, this would require a 100-hp. boiler. For a Corliss engine the steam consumption is approximately 25 lb. per horsepower hour. At 125 horsepower this would give 125×25, or 3100 lb. of steam required per hour, and by the same process as before this would require a 105-hp. boiler. A plain slide valve throttle engine would require about 45 lb. of steam per horsepower hour or for 100 horsepower, 4500 lb., which at 30 lb. per boiler horsepower per hour would require a 150-hp. boiler. A compound Corliss ought to have a horsepower for about 18 lb. of steam per horsepower hour, or for 200-horsepower engine would require 3600 lb. per hour, which would require about a 120-hp. boiler.

2. In this problem the moment of the valve itself is $4 \times 3 = 12$ inch pounds. For the lever the weight will act at 18 in. from the fulcrum and it has a volume of $\frac{3}{8} \times 1\frac{1}{2} \times 36 = 20.2$ cu. in., and a cubic inch of iron weighs about 0.24 lb., so that the weight of the lever is 4.85 lb. and its moment in inch pounds will be this value times 18, or 87 approximately. The cast ball would have a volume of 113.1 cu. in., and from this must be taken a volume $\frac{1}{2} \times 2 \times 6$, or 6 cu. in., leaving a remainder of 107.1×0.24, or 25.6 lb., and if

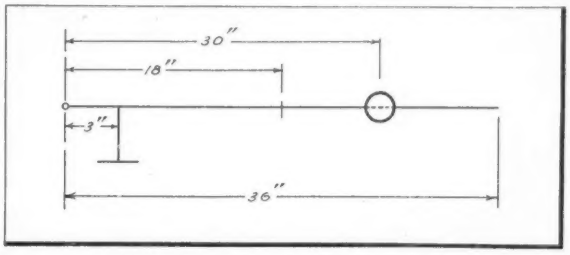


DIAGRAM OF SAFETY VALVE LEVERS

this acts at 30 in. from the fulcrum the moment will be 25.6×30, which is 768 inch pounds. The total moment of valve lever and ball will then be $768 + 87 + 12$, or 867 inch pounds. The total pressure required against the bottom of the valve will then be $867 \div 3 = 289$ lb. As the area of the valve is 6 in., the pressure required to lift the valve will be $289 \div 6$, or 48.1 lb.

3. The girth seam or any other seam should not come over a bridge wall if it can be helped, because the bridge wall tends to throw the gases up against the boiler shell and give extreme heat at this point. This causes great activity of any acids or foreign matter which may lodge in the seam, and this will tend to cause pitting, also the heating of the metal, if there is any sediment lodges along the seam, tends to weaken the joint, and the joint itself is weaker than the rest of the plate. A. L. R.

Boiler Reinforcement

WILL you kindly solve the enclosed problems indicated by the illustration, showing efficiency of the 3 types of reinforcement across the tube holes in boilers? Please state whether efficiencies relate to plate alone, or are to be taken as the combined plate and reinforcement strip. E. D. B.

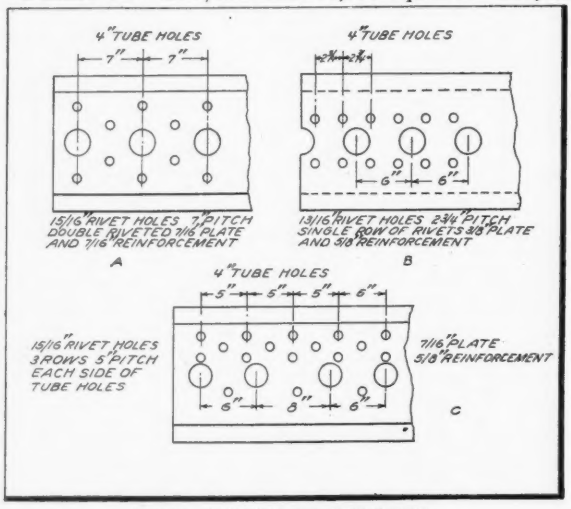
My questions and calculation refer to the tube reinforcements of boilers, such as the cross drum B. & W., the Flanner boiler, made in Toledo, and the Munoz w. t. boiler, now not made, but repairs still sold by the B. & W. Co. If you will consult the construction of these boilers, you will see that the tubes, where entering the drums, pass through a heavy plate riveted onto the shell of the drum. Now, what I want to know is, how much has the shell been

weakened or strengthened by this plate riveted on; in other words, what is the efficiency at this point and how calculated? E. D. B.

A. Figures for shearing, crushing, and tensile strengths vary, of course, with different steels, but for purposes of discussing the problems, we will assume 95,000 lb. crushing, 45,000 lb. shearing, and 60,000 lb. tensile, strength. The results obtained with these figures would, of course, be divided by a factor of safety, say 5 for working conditions. The different joints or reinforcing strips for shells of water tube boilers, where the tubes enter it, are lettered in sketches as A, B, and C. The distance the rows of rivets are apart, is not stated, but it is assumed that it is sufficient to prevent possible tearing from hole to hole, or from hole to edge of plate, say from 1½ the diameter of the rivet to possibly 3 times the diameter. Following is a discussion of each case.

CASE A

Tensile strength of shell with no holes, taken 7 in. wide to get typical sample, 7 times 7/16 times 60,000 equals..... 183,750
Tensile strength through row of rivet holes, 7 minus 15/16 times 60,000 equals..... 159,100
Tensile strength through tube holes, 7 minus 4 times 2 times 7/16 times 60,000 equals.. 157,500


4"TUBE HOLES
7" 7"
15/16" RIVET HOLES 7" PITCH DOUBLE RIVETED 7/16 PLATE AND 7/16 REINFORCEMENT
A
4"TUBE HOLES
6" 6"
13/16" RIVET HOLES 2¾" PITCH SINGLE ROW OF RIVETS 3/8" PLATE AND 3/8" REINFORCEMENT
B
4"TUBE HOLES
5" 5" 5" 6"
15/16" RIVET HOLES 3 ROWS 5" PITCH EACH SIDE OF TUBE HOLES
7/16" PLATE 5/8" REINFORCEMENT
6" 8" 6"
C

RIVET SPACING OF PROBLEMS

Crushing strength on edge of rivet holes, 2 times 7/16 times 13/16 times 95,000 equals 66,500
Shearing strength of rivets, 2 times 0.69 (area of rivet) times 45,000 equals..... 62,100
Efficiency of joint, the least strength divided by the strength of plate, 62,100 divided by 183,750 equals..... 33%

CASE B

Tensile strength of shell with no holes, taken 6 in. wide to get typical sample, 6 times ⅜ times 60,000 equals 135,000
Tensile strength through row of rivet holes, 6 minus 2 times 13/16 times ⅜ times 60,000, equals 98,500
Tensile strength through tube holes, 6 minus 4 times ⅜ plus ⅝ times 60,000 equals..... 120,000
Crushing strength on edge of rivet holes, 2 times 3/16 times ⅜ times 95,000 equals.... 53,000
Shearing strength of rivets, 2 times 0.518 (area of rivet) times 45,000 equals..... 46,600
Efficiency of joint, 46,600 divided by 135,000 equals 35%

CASE C

Tensile strength of shell with no holes, 14 in. wide, to get the typical sample, (as it takes 15 in. to get typical sample of rivet holes, the rivet cases are multiplied by 14/15 to reduce to same conditions), 14 times 7/16 time 60,000 equals..... 369,600
Tensile strength through row of rivet holes, 14 times 7/16, minus 3 times 15/16 times 7/16 times 14/15, all times 60,000 equals.. 304,000
Tensile strength through tube holes, 14 minus 2 times 4, times ⅝ plus 7/16, all times 60,000, equals..... 382,500
Crushing strength on edge of rivet holes, 9 times 7/16 times 14/15 times 95,000 equals 326,800
Shearing strength of rivets, 9 times 0.69 (area of rivets) times 14/15 times 45,000 equals 261,000
Efficiency of joint, 261,000 divided by 369,600 equals 71%

"The object of putting reinforcement strips across the boiler tube holes may be because of several reasons; because of some crack which has developed in the head between the tubes, and it is desired to put on a patch, rather than to take out the head and put in a new one. Ordinarily the tubes are set with too close centers to give sufficient bridge to give place for proper rivets and retain the hole in the strip in which to expand new tubes, or it may be the intention to put strips over a row where the tubes are to be taken out. There is seldom room for rivets in a patch of this kind. In your question you have shown the spacing of the tubes in out direction only, but the presumption would be spacing in the other direction would be the same, was this intended? The pressure on the new space would have to be carried by the tubes either side of the row removed. It would be necessary to have the steam pressure carried, to give rational answer to the various designs submitted, and it is likely it would be necessary to run tie rods from end to end of boiler to support the pressure on this bridge."

Paul M. Chamberlain.

Eccentric That Slipped

HOW would you reset an eccentric which had slipped without removing the steam chest cover? G. A. W., in the April 15 issue.

A. Disconnect the drain pipes from the cylinder cocks or if more convenient the indicator connections may be used. Center the engine at the head end, after which admit a little steam to the cylinder and, if the rocker or valve connections are direct acting, turn the eccentric around the shaft in the direction the engine is to run until steam issues from the drip valve on that end; fasten the eccentric at this point and turn the crank to the opposite center and turn a little steam into the cylinder again and if there is any lead steam will appear at the drain valves on that end, if none is visible a slight backward shift of the eccentric should produce the desired results unless there is something wrong with the construction of the valve.

Should the motion transmitted to the valve be indirect, the eccentric should be turned around the shaft apposite to the direction of the crank, following out the same procedure outlined above.

If this work has been carefully done the engine should run till an opportunity is given to remove the steam chest cover or an application of the indicator made to determine the correct valve adjustment.

A. K. Vradenburgh.

Problems For Discussion By Readers

What Would You Do If You Had These Conditions To Meet?

Voltage Drop of Generator

I SHOULD be very glad if some reader could suggest a remedy for the difficulty which I am at present experiencing with a generator. In an installation driven by a gas engine a compound wound generator supplies some 25 lights and two motor fans (each about 14 amps., at 110 volts.) The generator is of the open protected type, and when started up at its correct speed the voltage with the load on is 110 volts, but after about an hour or so the voltage drops to 90, although the speed remains the same. No shunt regulator is in circuit. What is the cause of this 20-volt drop? I may mention that the machine runs quite cool, and that it has been tested, and all connections found correct. C. M.

Unusual Indicator Cards

IN reference to the phenomena of the "unusual indicator cards" shown in March 15 issue of Practical Engineer:

The wavy expansion line could be produced by an accumulation of water in the passage from the engine cylinder to the indicator and I believe this to be the case; the inertia of this accumulated water is what produces the waves in the expansion line. The irregularity of the undulations shows this, especially on cards 3 and 4, where the inertia of the water carried the admission line too high and then the inertia of the same body caused the high admission line to be carried out to a considerable distance on the steam line. It is plain that without the side connections water has less chance to accumulate in the connections between the indicator and the engine cylinder, and that is why a good card resulted when the side connections were removed.

The middle line on the expansion curve of card two appears to be less effected by the water in the pipe connections than does the others; this doubtless is due to a lesser volume of water in the connections. In my mind this is the only explanation accounting for the wavy expansion line. Thos. C. Robinson.

Expansion Bends in Pipe Lines, Check Valve Problem

I NOTE problem of N. F. S. page 271 of the March 1 issue of Practical Engineer. My opinion is that the check valves have too much lift, and besides, the two 1½-in. feed pipes from main to boilers, are too large for the 2-in. main to supply steadily. The cross sectional area of each 1½-in. pipe is 1.77 sq. inches, together making 2×1.77=3.54 sq. in. area, while the cross sectional area of the 2-in. pipe is but 3.1416 sq. in. True, not a great difference, but enough I believe to cause an unsteadiness in water delivery, and, with an excess of check-valve lift, the pounding N. F. S. complains of. The two 1½-pipes can take away the water faster than the 2-in. pipe can supply them, causing an intermittent action of flow.

If it is not practicable, nor desirable to change the 1½-in. piping to the boilers to 1¼-in., which would be more nearly correct under the conditions, the next best thing will be to reduce the lift of the check valves, which will be equivalent to reducing the size of the delivery pipes between the check valves and the boilers. The reduced lift will also do away with excessive pounding as complained of by the correspondent. A valve should lift from its seat to the extent of one-quarter of its diameter. Nothing is gained by having any valve lift more than that, although a great many valves are so made that considerable more than one-quarter diameter lift is obtained.

In our problem the check valves are 1½ in. diameter. ¼×1.5=.375, or ⅜ in. is abundant lift for those valves. No more water would go through them, if they had ¾ in. lift, the greater the lift, the harder the blow struck by the valve on its seat. I would suggest that N. F. S. reduce the lift of his check valves to about 5/16 in. to allow for the two 1½-in. pipes containing a greater cross sectional area than the main 2-in. pipe. No doubt that 5/16-in. lift will allow all the water to pass that each boiler requires, with a moderate speed of pump, and yet make the pump live up to its work. This means that seldom will the checks seat while the pump is working, and they, the valves, certainly will not seat as noisily as now. Doubtless he will find the lift more than the ⅜ in. which I have explained. Should he decide to act on the foregoing suggestions or in fact whatever he may do to get results, I hope he will tell Practical Engineer readers about it, and let us all share in the benefit of the knowledge obtained.

Before concluding this contribution I would also like to express an opinion on the broken expansion loop which appears on page 271, same of the same issue, since the correspondent invites explanations from other readers.

When considering the piping as a whole, and as shown in the sketch, the linear expansion will be approximately 11 inches, as the correspondent has stated in the article in question. The co-efficient of expansion for iron pipe is about .00000686 for each degree difference of temperature per foot length, so that assuming an external temperature of 40 deg. F. we have: 462×(340—40)×.00000686=.950796 ft. and .950796×12=11.4 inches expansion, or contraction, as the case may be.

But it seems to me that the part of the piping that the expansion loop which cracked had to take care of, is about ⅔ the entire length of piping, or ⅔×462=308 ft. Then, 308×(340—40)×.00000686=.633864 ft., and, .633864×12=7.6 in. expansion or contraction to be endured by that one loop, which I believe to be too much. The material may perhaps have been poor, but even for the best 7.6 in. is too much for that one bend. I believe one more expansion loop or bend, would take care of the case. Charles J. Mason.

PRACTICAL
ENGINEER

PUBLISHED ON THE FIRST AND FIFTEENTH OF EACH MONTH
At 537 So. Dearborn Street, Chicago, Ill., by the
TECHNICAL PUBLISHING CO.
New York, 150 Nassau St. Cleveland, Am. Trust Bldg.

Subscription Price One Dollar a year in advance to any Post Office in the United States or Mexico or United States possessions.

To Canada One Dollar and Seventy-five Cents; to Other Countries Two Dollars and Fifty Cents a year. Single copies 10 cents.

Address all letters and make all checks and money orders payable to Technical Publishing Co., 537 S. Dearborn St., Chicago, Ill. Notify us at once of any change of address, giving the old and the new address, so that your paper may always reach you promptly.

Any advertiser is invited to examine our paid subscription lists and Post Office mailing receipts at any time.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the Act of March 3, 1879.

Circulation of this issue, 23,500

CONTENTS

Plant at the Norwich State Hospital. By Charles L. Hubbard. Illustrated 499
Does the Indicator Lie? By E. S. Libby. Illustrated....503
The Fuel Cost of Making Steam. By S. Milton Clark....507
Conveying and Elevating Machinery. By Reginald Trautschold. Illustrated 509
Aids in Engine Troubles....511
The Use of Compressed Air in Boiler Shops. By Thomas Aldcorn 512
An Air Compressor's Experience. By Geo. H. Wallace. Illustrated 515
Every-Day Calculations. By Richard Howarth. Illustrated 516
Uniform Boiler Specifications 517
Electricity Rectifiers. Illustrated....518
Engine Test From the Indicator Diagram. By J. Paul Clayton. Illustrated 522
Relations Between Diameter and Speed of Pullevs and Gears. By John B. Sperry. Illustrated....526
Ice Making and Refrigerating Machines. By William H. Biesley. Illustrated 528
Arctic Double-Single Acting Ammonia Compressor. Illustrated 529
Oiling Systems that Pay 100 Per Cent Dividends. By Wm. L. Morris....531
Letters Direct from the Plant: High Steam Line on Crank End. Repairing Smokestacks. The Turbine Indisposed. The Back Pressure Line. Boiler Regulations. Card Comment. A Locomotive Explosion. Setting Eccentric Without Removing Steam Chest Cover. Supplying Water in Factory. Reusing Oil; Leaking Engine Valve. Illustrated....532
Successful Kinks from the Plant: Tightening a Blower Fan Hub. Air Out of Trap. Using Brass Polish. Illustrated 537
Questions Answered and For Answer. Setting Valves of an Erie City 4-Valve Engine. Disposal of Sawdust and Shavings. Capacity of Ice Tank. Boiler Questions. Boiler Reinforcement. Eccentric that Slipped. Illustrated 538
Problems for Discussion by Readers: Voltage Drop of Generator. Unusual Indicator Cards. Expansion Bends in Pipe Lines. Check Valve Problem....541
Editorial: Does it Pay to Keep Records?....542
Correction on Data Sheet....542
Power House Troubles. By R. A. Cultra....543
Some Modern Methods in Belt Driving. Illustrated....544
A New Copper and Asbestos Gasket. Illustrated....545
Non-Overflow Filler for Hand-Oilers. Illustrated....546
Elevator Guide Lubrication. Illustrated....546
Ziermore Pressure Regulator. Illustrated....547
News Notes 547
Catalog Notes 549
Trade Notes 550

DOES IT PAY TO KEEP RECORDS?

Can anyone conceive of a large manufacturing company or mercantile establishment conducting a business without keeping a set of books? Even the smallest of dealer keeps records of his business by some system.

But what of the power plant? It is the exception rather than the rule to find any adequate system of keeping records and in a great many instances no records whatever are kept, nor can an indicator be found. Under such conditions the cost of operation and repairs, the proper valve adjustment of the prime movers, the relative evaporation per pound or ton of coal is mere guesswork.

Why not place the plant on a business basis and consider the earning value of each piece of machinery.

Business men, as a rule, are not engineers and little understand the value of economies in the plant. Let the engineers take the initiative and keep a complete record for several months and find out where the "leaks" are and set about to correct them, and then compare each succeeding month with the previous month.

In 6 months' time the engineer can go to the "boss" and intelligently show him what saving has been effected, the condition of the machinery; just how much coal it has taken to produce a kilowatt of output at the switchboard. It is quite safe to say that the engineer will rise a great many per cent in the "boss's" estimation and be recognized as a real factor in the conduct of the business.

In an isolated plant in the middle west the chief engineer keeps a ledger account with every piece of apparatus in the engine and boiler room and can, for example, tell at a glance just how much packing has been used in a certain boiler-feed pump, how many hours' labor have been spent on it and many other details. This is an example of a plant conducted on a business basis.

Does it pay to keep records?

Ask anybody who has persevered in it until he could get a real comparison and analysis of costs.

Now is the time to make a start. What item in your plant would you like definite information about? Can we be of help in showing you how?

CORRECTION ON DATA SHEET

In the issue of April 15 the data sheet on Page 95, the upper left-hand has the equation for the maximum pitch for screwed staybolts. In the setting of this equation the radical sign was omitted by the compositor. The equation should read:

$$\text{Maximum pitch} = \sqrt{\frac{66 \times (t+1)^2 + 6}{P}},$$

the symbols being as given on the data sheet. While you are thinking of it, turn to the April 15th issue and make this correction to avoid future annoyance in trying to use the equation.

POWER HOUSE TROUBLES

By R. A. Cultra

TROUBLES of an assistant or watch engineer in a central power station are so many that it would be impossible to relate the accidents he may have on a single watch, especially if he has charge of both the steam and electrical machinery including the switchboard. The consolidation of many small electric railway companies necessitates the establishment of fewer but larger power stations and the interweaving of the feed lines in such a manner that should one station lose a generating unit, thus decreasing its efficiency, the nearest station having a surplus of capacity, hence higher voltage, would immediately pick up the load, with probably a slight drop in voltage, thus maintaining the service without noticeable delay.

At one time I was running a 1000-hp. cross-compound, Greene engine, anybody who has seen these engines knows how sensitive the governors are and can appreciate the ease with which they are operated in power stations. It is always better to have an engine that will run on 3 legs, than not run at all. The arrangement of the valve gear is such that the toes are engaged by tappets, which are connected with the reach rod of the governor by a right angle lever and knuckle joint; and the little short link stop or safety is tripped by the governor dropping low enough to bring this end of the reach rod down on a set screw, thus throwing the link in a vertical position and allowing the tappets to drop flush with the sliding bar and table so as not to engage the toes.

The day's run had but 45 min. to complete it. I was busily engaged replacing the brushes on a large machine nearest this one when I noticed the relief valve on the receiver open suddenly and the engine began to labor heavily, the relief valve closing immediately. Glancing at the switchboard, I noticed the ammeter registered 1200 amperes. As the voltmeter was on a bracket extending from the board, I could not see it, so I ran to the board and found that it registered zero, showing the machine to be reversed in polarity.

Not knowing how many cars were out, I at once prepared to start the large machine, but this required about 25 min. on account of the generator requiring considerable time to build up its voltage. With the exception of one line, the cars were all due in the barns, so knowing that the motormen on the cars would reverse their controller and not be delayed, I concluded to wait a few minutes before putting on the other machine, as doing so meant the shutting down of the first one and putting out all the lights in the cars and car barns, also stopping the cars.

To my surprise, the cars were reported in ahead of time and the engine was stopped for the night. I then set to work to change the polarity back. The old system was to raise all the brushes off the commutator, but to do this and replace them would require about 2 hr. on such a large machine; so instead I disconnected the cable to the brush holder bus bar, bending it back out of the way of contact, and after starting the large machine, I put in the circuit breaker and switches for a few seconds, thus driving a current around the field coils, and started the machine up. The voltmeter showed the voltage, indicating that the polarity was changed back to its proper direction.

Investigation showed that the oiler, being industrious, while wiping around the governor had accidentally tripped the reach rod on the low pressure side. The relief valve immediately opening on the receiver gave warning of what had happened and grabbing the reach rod, he pushed it back in position, thus making the engine dig heavily into the load, the receiver relief valve closing immediately.

Having placed the machine in running order, I inquired of different power stations on the lines, of voltages carried by each and found that in one running a rotary converter, the engineer in charge had expected such an accident to happen to his converter from high voltage from the other plants and had run the voltage on his machine up to 570 volts. This was 20 points higher than the voltage carried in our plant at full load, and as the machine was wound to carry 500 volts at no load, when the engine was tripped, thus reducing the voltage to about 300, there was a difference sufficient to allow the higher voltage to reverse our machine.

After this accident, to prevent a recurrence, the man used over care in keeping the voltage low on the machines in his plant, and I am sorry to say, had the pleasure of seeing the rotary converter go up in flames. Normal voltage is all that can be carried under such conditions and it must be kept normal.

In addition to this, the condenser got hot from the increased load and the vacuum was dropping fast. This was stopped by opening the inlet valve more. The fireman also had his share of trouble, for the increase in load demanded more power and he immediately put another boiler into service and kept the plant running. It is safe to say in the 2 stations there was an extra consumption of 3 tons of coal.

Engine Run Three Legged

THIS engine has carried a good load running with 3 of the 4 ends of the 2 cylinders, or 3 legged.

The steam valve stems connect to a small crosshead by a bolt passing through the stem and crosshead at the opposite end of the rocker shaft which carries the toes. On one occasion, this bolt broke, leaving the valve open. Putting a block under the nut on top of the socket, thus holding the toe up from the tappets, a piece of wire was looped and wrapped around the piece of bolt and stem and with the use of a 6-ft. bar, the valve was finally pulled shut. In the meantime, the steam was roaring through the cylinder every time the exhaust valve opened, thus exhausting the receiver and reducing the vacuum.

The condenser pump being separate, was speeded up faster and maintained a vacuum fluctuating between 20 and 25 in. but when the valve was finally closed, the receiver pressure went up, opening the relief valve until the governor shortened the cutoff on the high-pressure side, thus reducing the receiver pressure, causing the engine to slow down a trifle until the governor again lengthened the cutoff on the high-pressure side. Plainly speaking, the governor was reaching to maintain an equilibrium at normal speed. After lengthening the cutoff on the crank end of the low-pressure cylinder, the engine regulated all right.

A new bolt was procured, the old one punched out and with the starting box wrench, the crosshead was moved over to meet the valve stem and the new bolt put in, shortening the cutoff on the low-pressure side again. I pulled the block out from under the toe, allowing the valve to operate and brought the receiver pressure to normal by shifting the cutoff on the low-pressure side. As the receiver pressure on this engine varied with the load, I had completed this repair job without stopping the engine or causing any delay in the service.

Power Apparatus in Shop and Market

New Ideas In Making, Buying and Selling

SOME MODERN METHODS OF BELT DRIVING

Achievements in Belt Drives which Make Belt Systems More Flexible, Reduce Space Requirements and Increase Efficiency of the Transmission System

DURING the past decade the possibilities of belt transmission have been lost sight of by many engineers and superintendents of machine shops largely because of the development of motor drives; there are, however, many instances where a belt will do the work more efficiently and save the purchase of a motor, as well as arrangements for bettering the operation of a belted motor, and none of these should be overlooked when laying out plan for transmitting power.

Figure 1 shows how one shaft is driven from another with a considerable distance between their ends with the shafts set at substantially right angles to each other and at different elevations from the floor level. The drives shows how a minimum obstruction to the space above is obtained and also the free use of the doorway. A lattice work guard is placed around one pulley and underneath the belt, and simple iron brackets are driven into the wall so that in case the belt breaks it may be caught and thus prevent danger

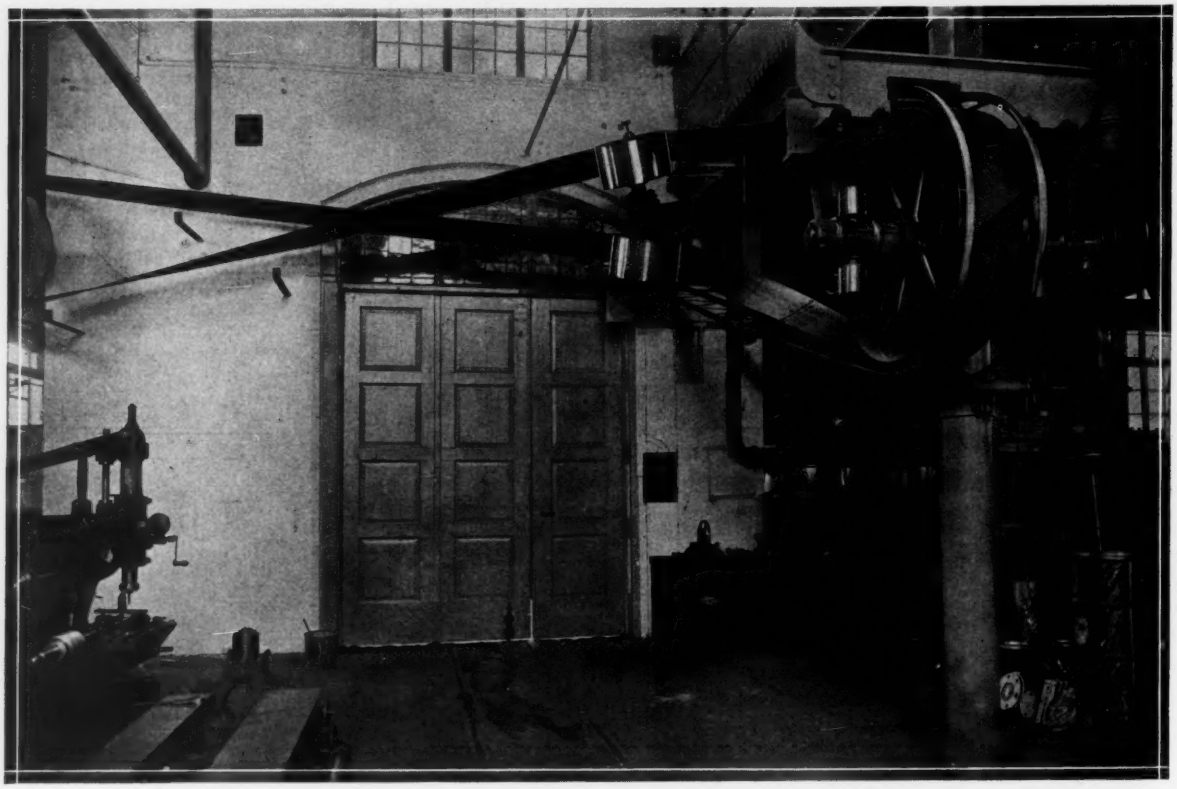


FIG. I. TRANSMISSION AROUND A CORNER BY MEANS OF A BELT AND METHOD OF PROTECTING AGAINST RUPTURED BELT

A study of power transmission by means of leather belts has been made by the Chas. A. Schieren Co., of New York, and a number of the achievements are shown in the accompanying illustrations. The relative ease with which 2 shafts can be connected together for driving purposes where their relation to each other seems to make the problem impossible or impracticable is shown in Figs. 1 and 2.

and a destructive accident.

By means of what is known as a Bamag wheel, 2 shafts at an angle with each other but close together are connected by one belt. This arrangement, shown in Fig. 2, is regarded as taking the place of the bevel gear with higher efficiency and less noise than with the gears.

Belt drives of the common arrangement are limited

in regard to the minimum distance between pulleys, but this limitation has been overcome by the Lenix system, which is an idler mounted in a freely moving carrier, but equipped with weights which may be varied in position to control the pressure which the idler itself puts on the slack side of the belt. Located near a small driving pulley, it serves to give a maximum arc of contact between the belt and the pulley, and the freedom of suspension of the idler allows it to compensate for variation in conditions of power demand. The special advantage of such an arrangement is that not only may a large ratio of speed reduction be secured with one belt, but the distance between driving and driven pulleys be minimized without excessive tension of the belt.

Figure 3 shows an application of the Lenix system where a relatively low speed hydraulic pump is driven by a high speed motor, the driving and driven shafts being practically vertical one over the other. Under ordinary conditions the belt tension with a single reduction of speed would cause no end of trouble with hot bearings, but with the Lenix idler it is found that the required difference in belt tension of the tight and slack sides, in connection with the increased arc of contact secures the proper power transmission without giving rise to high belt tension.

In another case in a building power plant in New York, a belt-driven dynamo was brought 9 ft. 6 in. nearer the steam engine by the use of the drive, with a resultant saving in floor space of considerable area as well as a driving of the dynamo up to speed. Under the former arrangement the belt slipping made it difficult to keep the dynamo up to voltage and sometimes even to keep the belt on the pulley. In connection with the latter experience the Smidth Company has collected information showing a remarkable reduction in friction loss. The tension in the tight side of the belt was formerly 944 lb. and is now 522 lb. and the tension in the slack side was 470 lb. against 48 lb. at the present time. This leaves the tangential force 474 lb. in the 2 cases.

It has been figured out that a total friction loss in the bearings of the driving and driven pulleys was 2.953 hp. and the loss in the belt from bending over the pulleys, 0.045 hp. The bearing friction loss with the Lenix drive is given as 1.24 hp., and the loss in the belt from bending over the pulleys, 0.0275 hp. The slip of the belt on the pulleys is given in the ratio of 2.37 to 0.312 for the 2 cases. The driving pulley in this case is 66 in. and the driven pulley 17 in. The arc of contact when the distance between centers was 16 ft .was 196 deg. for the driving pulley and 164 deg. for the driven pulley, while the arcs with the reduced distance of 6 ft. 6 in. is 235 to 242 deg. for the driving pulley and 235 to 251 for the driven pulley. A 12-in. belt ⅜-in. thick was formerly used and now a 10-in. belt 3/16-in. thick suffices.

Figure 4 shows the control of a speed regulating device involving a conical pulley known as the Fadenschutzer Bamag, and is shown provided in a spinning mill where it is desirable to change speed during operation. It is claimed that the device extends the life of the belt.

FIG. 2. TRANSMISSION BETWEEN CROSSED SHAFTS CLOSE TOGETHER

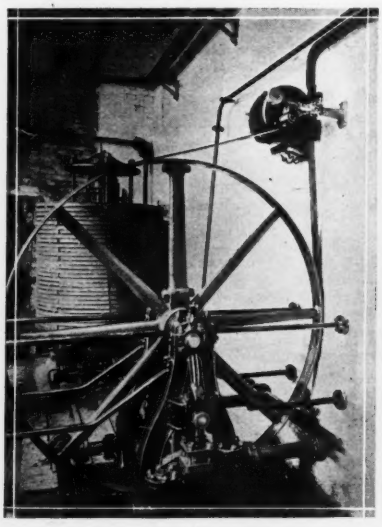


FIG. 3. AN APPLICATION OF THE LENIX DRIVE

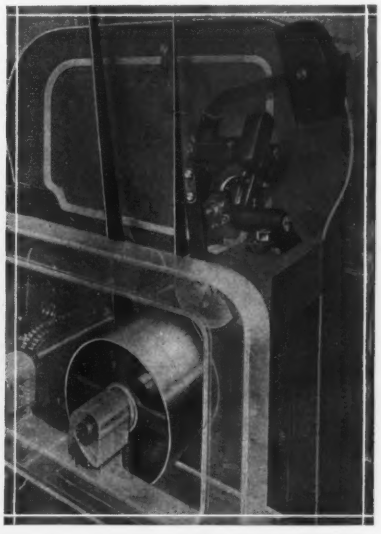


FIG. 4. BAMAG THREAD PROTECTOR SPEED REGULATOR

A NEW COPPER AND ASBESTOS GASKET

THE Devo Gasket is the latest Goetze product and is intended for high and low pressures. It is particularly adapted for superheated and saturated steam, and consists of a corrugated steel gasket, entirely embedded in an asbestos covering, which is thoroughly graphited throughout. It is ⅛ in. in thickness, but can be compressed to 1/16 in.

One of the advantages of the gasket is that no metal comes in contact with the flange surface, and as a result the gasket is noncorroding and proof against elec-

SECTION OF THE DEVO GASKET

trolysis. Being deeply corrugated it will make steam tight joint, even where the flange surface is unusually rough. This gasket does not need to cover the whole flange surface, but can be applied inside the bolt holes and can be fully tightened up without any strain on the

flanges. This method of application means a saving in the cost of gaskets on account of the smaller size required.

The Devo gasket is manufactured by the Goetze Gasket and Packing Co., New Brunswick, N. J.

NON-OVERFLOW FILLER FOR HAND-OILERS

FOR use in factories, textile mills, oil houses, etc., where hand-oilers are used to any great extent, S. F. Bowser & Co., Inc., Ft. Wayne, Ind., is placing on the market an outfit designed for storing lubricating oil, and is provided with a quick-acting pump which is used in filling the different sized hand-oilers. The pump is provided with an adjustable table or platform which operates with a lever. The hand-oiler is placed on this table and the lever is pushed down, which throws the oiler into the proper position, fitting the nozzle into the opening of the hand-oiler. The height of the table can be adjusted instantly to accommodate it to the different height oilers. When the oiler is in the position to be filled, the nozzle of the pump fits into the oil can, making a perfectly oil-tight connection, and a few quick strokes of the pump fills the can. Any amount over the capacity of the oiler is discharged back into the storage tank by means of an overflow line provided for that purpose, which positively prevents spilling the oil or mussing the can. The cabinet is provided with a metal hood which may be closed and locked, thus insuring clean oil.

The outfit is guaranteed fire-proof, is made of sheet steel, finished in bronze green, or where desired, the finish may be changed to conform to the finish of the room in which it is to be used.

Several years of experimental work were necessary in order to complete this equipment, which embodies every feature that is necessary in an outfit for filling hand-oilers.

ELEVATOR GUIDE LUBRICATION

FEW engineers realize the large amount of power lost by friction between the elevator shoes and guides when they are not properly lubricated. This loss of power was, however, forcibly brought out in one of the large department stores in Philadelphia. It was noted that after the guides were thoroughly greased the cars operated satisfactorily, but within a few days they commenced to drag on their guides, making it necessary in about a week to cut down the load on the elevators, so that they would only carry about ¾ their rated capacity. While in this case the loss of power was easily noted because the elevator machinery was not powerful enough to overcome the results of excessive friction, it is not generally so easy to detect these losses, for if the elevators are operated by electric motors, these motors will draw enough extra current to make up for the loss of friction, but the owner has to pay for this in the high bill for power that naturally results.

To overcome these and other difficulties, the Economy Elevator Guide Lubricator has been perfected. The main body of the lubricator is hollow casting, to which is attached a special compressed air grease cup. In ordinary operation these grease cups have to be filled once every 8 to 12 weeks, and an occasional turn of the top nut so compresses the air entrapped in the cup that there is always sufficient pressure to force the grease out through the arms of the lubricator to the guide rails in a thin ribbon exactly where the guide shoes bear.

Due to this fact the Economy lubricator effects a remarkable reduction in the amount of grease used. For instance in one of the elevators in the 168th Street Station of the New York Subway, this lubricator required only 30 oz. of grease for lubrication a month, whereas with the old hand method the average consumption was 480 oz. for the same length of time. At the same time a reduction in the amount of power necessary to operate the elevators was noted.

BOWSER NON-OVERFLOW FILLER

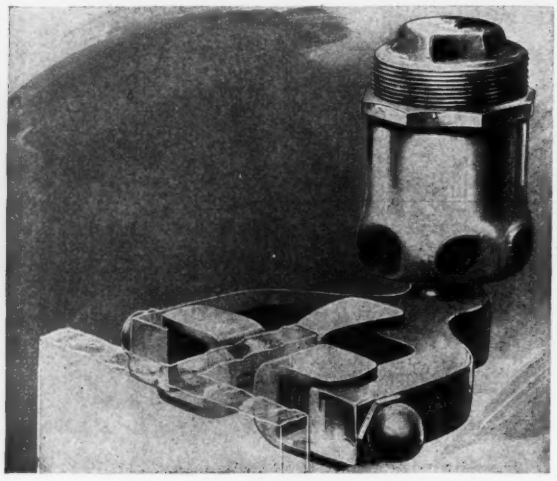


FIG. 1. ELEVATOR GUIDE LUBRICATOR FOR STEEL RAILS

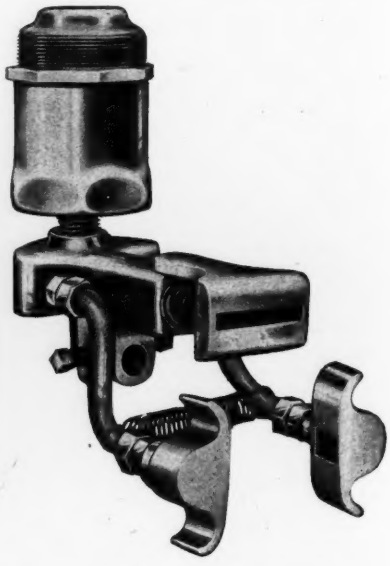


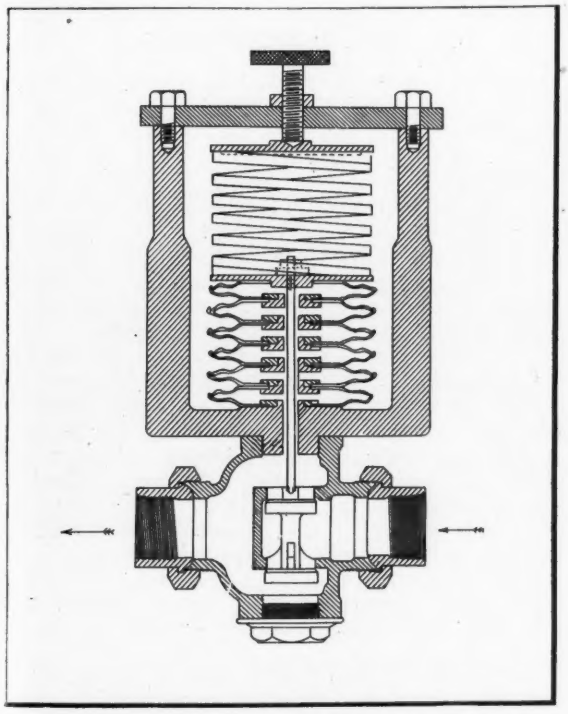
FIG. 2. GUIDE LUBRICATOR FOR WOODEN ELEVATOR RAILS

The Economy method of applying grease also decreases the liability of injury to employes and by saving excess lubrictation on the rails the fire hazard is reduced. It has been found that large amounts of lubricant in elevator hatchways are as effective as a train of powder in carrying fire from one floor to another.

The Economy Lubricator is manufactured by the Peterson Engineering Co., 50 Church Street, New York.

ZIERMORE PRESSURE REGULATOR

FOR regulating the pressure of liquids the Ziermore pressure regulator has a number of distinctive features, it is made of silver, German silver and bronze. The body, the yoke, the double seated balanced valve, the adjusting screw and nuts and valve stem are all made of bronze. The diaphragms are made of silver and German silver with bronze connecting fittings. These fittings are made male and female and are soldered with silver to the German silver diaphragms, which makes these fittings part of the diaphragms and makes it possible to build as long a battery of multiple diaphragms as is desired to suit the throw of the valve and also makes it possible easily to add a diaphragm to or take it from the battery.



CROSS SECTION OF ZIERMORE PRESSURE REGULATOR

The lower end of the battery of diaphagms is anchored to the threaded lug of the yoke, while the upper end of the battery is free to move with pressure on the inside of the diaphragms. To the upper end of the diaphragms is attached a bronze plate to serve as a spring support, a shoulder for the diaphragm and an anchorage for the valve rod.

The valve rod passes freely through the battery of diaphragms without friction. The upper end of the rod being anchored to the movable end of the battery of diaphragms and the lower end of the rod being anchored to the valve disc causes the valve disc to move toward or away from its seats as the battery of diaphragms inflates or deflates with any change of pressure in them.

According as the spring tension is set against the top of the battery of diaphragms, by the aid of the adjusting screw, the low pressure is produced and controlled.

The fluid passes through the regulator as is indicated by arrow. The low pressure, only, has access to the battery of diaphragms and enters them from the low-pressure side of the regulator, through the same port which the valve rod enters.

The slightest change of the low pressure will cause the battery of German silver diaphragms to move, when of course, the valve disc must move exactly the same distance. With any change of low pressure each individual diaphragm moves, which in turn moves its neighbor, thereby, multiplying the movement of the anchorage of the top of the rod which carries the valve disc with it.

The construction of this regulator is such that it may be placed in service in any position without interfering with its sensitive action and should be admirably adapted for marine and railroad service, as jar or motion will have no effect upon it. Having no corrosive parts nor small ports it is suitable for controlling steam, air, gas, water, oil and many kinds of acids. The valve discs and seats being made of a special grade of bronze and the battery of diaphragms handling the valve disc in such a sensitive manner the danger of wire-drawing is almost eliminated, while chattering is unknown.

All sections exposed to view and each movement of the diaphragms and valve disc in sight, repairs are seldom needed and its operation is most satisfactory.

This regulator is the product of the Ziermore Regulator Co., of Johnsonburg, Pa.

NEWS NOTES

THE SPRING MEETING of the American Society of Mechanical Engineers will be held in Cleveland, Ohio, May 28-31. The professional sessions, which are open to the public, will be held in the hall of the Chamber of Commerce building and the hotel headquarters will be at the Hollenden. Papers will be read on the Cylinder Performance of Reciprocating Engines, the Equipment of a Modern Flour Mill and Features of the California Gold Dredge at the Wednesday morning session. A simultaneous session of the Gas Power section will take up a paper on National Gas Engineering. Wednesday evening a lecture on Sound Waves and How to Photograph Them will be delivered and on Thursday the morning session will be devoted to New Processes of Chilling Cast Iron, Strength of Steel Tubes, Pipes and Cylinders, Control of Steam Cylinders and Water Control, and Speed Regulation in Hydro-electric Plants. Friday morning's professional session will be devoted to The Development of Large Steam Turbines, Thermal Properties of Steam, Temperature Reduction by Condensing Water Reservoirs, and Capacity of Safety Valves.

Entertainment features of the meeting will be a reception on Tuesday evening, luncheon and excursion to manufacturing plants Wednesday afternoon, a lake excursion Thursday afternoon, formal reception Thursday evening, and luncheon and excursions to Akron and Barberton on Friday afternoon.

THE ASHTON VALVE CO.'s Chicago office has removed to 174 N. Market Street, two blocks west of its former location at 166 W. Lake St. The new quarters offer better facilities for handling its rapidly growing business.

MR. CECIL P. POOLE, who has been the junior editor-in-chief of our contemporary, Power, for the past 7 years, has severed his connection with that paper and will engage in consulting engineering in Atlanta, Ga., in partnership with Lamar Lyndon, of 60 Broadway, New York. The firm will operate as the southern branch of Mr. Lyndon's New York office, which will continue as heretofore. The Atlanta office will be conducted by Mr. Poole. During the past 10 or 12 years Mr. Poole has made a special study of electrical machine construction and of gas power engineering, and his knowledge of these branches of engineering ought to be of great assistance in his new work. He is widely known as a writer on both subjects and is a member in good standing of the American Institute of Electrical Engineers and of the American Society of Mechanical Engineers.

AT THE 24th ANNUAL CONVENTION of the American Boiler Manufacturers Association, the Secretary of the Supplymen's Association, was authorized to publish a list of the Boiler Manufacturers in the United States and Canada.

This list comprises 1000 names of Boiler Manufacturers in the United States and Canada, which have been verified through Mercantile Agencies, and by direct correspondence, making it authentic; and will be of interest to manufacturers of tools used in Boiler Shops, Material men, Mechanical Engineers, and Boiler Buyers.

The Book is also arranged with a column in which the credit rating and financial responsibility can be inserted. Price per copy $5.00. Copies can be secured from F. B. Slocum, secretary Supplymen's Association, c/o Continental Iron Works, West & Calyer Streets, Brooklyn, N. Y.

UNDER DATE OF MARCH 25th the Columbian Rope Company, of Auburn, N. Y., sent out announcements of the opening of a new branch house in Boston, at 131 Beverly St.

The company has been represented in the New England territory for the past two years by Mr. Alfred C. Clarke, who will continue with the company as manager of the new office.

Mr. Clarke has had many years of experience in the Cordage business. He entered the employ of the old Sewall & Day Cordage Company over 20 years ago, and from that time has been connected with the Cordage Business. When the Standard Cordage Company took over the Sewall & Day Mill, Mr. Clarke became their representative for New England, and stayed with them until he took his present position.

Mr. Clarke's experience in the Cordage business and in New England makes him peculiarly able to represent the company, and they are to be congratulated in having such a representative for this Territory.

Besides the Boston Warehouse the Columbian Rope Company owns its own Warehouse in the city of New York under the charge of Mr. George B. Granger, and also its Warehouse in Chicago in charge of Mr. W. V. Hawkins. These houses in the three important Cordage buying centers place the Columbian Rope Company in an excellent position to take care of rapidly increasing trade.

NATIONAL GAS ENGINE SHOW. Milwaukee, June 17-22. At this show, which will be held under the auspices of the National Gas Engine Association, the exhibition will be entirely on things pertaining to the gas engine. In the big auditorium one will find gas engines and devices which pertain to them and nothing else. Straight in front of the entrance will be 3 large gas tractors with engines running, the kind of machinery which is changing the entire farming industry of the West. Beyond these will be gas and gasoline engines of various types for all kinds of purposes, many of them in operation, and surrounding the central arena will be exhibits of accessories such as dry batteries, magnetos, spark plugs, clutch pulleys and other necessary apparatus in the gas engine installation. All of these engines and accessories will be in actual operation the same as in ordinary service, the engines using the same fuel that they would ordinarily use, so that actual operation of the engine, just how it works and the performance in every-day service can be studied.

The National Gas Engine Association will hold its semi-annual convention during the week of the show, and the papers will be read and discussion had on these papers by many men of eminent standing in the gas power industry. Information in regard to space for the show can be had by addressing O. C. Parker, La Crosse, Wis.

THE LAGONDA MANUFACTURING CO., Springfield, O., manufacturers of tube cleaners, tube cutters, water strainers, reseating machines and automatic cutoff valves have commenced work on a new 3-story office building, which will be modern, complete and absolutely fireproof.

THE EXECUTIVE OFFICES and New York show rooms of the H. W. Johns-Manville Co., manufactuerer of asbestos, mangnesia and electrical supplies, were moved on Apr. 20 to the new 12-story H. W. Johns-Manville Building, Madison Avenue and 41st St., New York City, from the old quarters at 100 William St., where they have been located for the past 15 years. This move marks the 54th anniversary of the company.

In the new quarters, the company will have the distinction of being one of the few manufacturing concerns which occupies an entire 12-story office building. In its entirety, the company now occupies over 2,657,160 sq. ft. of floor space or about 61 acres. The employes number approximately 5000 and there are about 425 salesmen.

Increased business interests in this and other parts of the country have necessitated the move. The large floor area and spacious rooms in the new building, will enable a much larger and more complete stock of goods being carried on hand than heretofore, and will also permit of a better supervision over the long chain of branch offices, warehouses, stores, and factories scattered throughout the United States and Canada.

FREDERICK S. PALMER has connected himself with the Metallic Packing & Manufacturing Company of Elyria, Ohio. as general manager of the automatic engine stop department. Having been occupied for the past 10 yr. in the design and sale of all makes of engine stops he is now in a position where he has an untrammeled opportunity to give the benefit of long and broad experience, having ample capital and a finely equipped factory at his command.

A BOSTON manufacturing concern that makes electric lights for automobiles has brought out a new outfit adapted particularly for aeroplanes. The dynamo weighs just under 20 lb., and is run by a belt or chain from the motor. The switch is placed on one of the uprights within easy reach of the operator.—Gas Review.

CATALOG NOTES

HARRISBURG FOUNDRY AND MACHINE WORKS have issued Bulletin No. 1 entitled "Considerations Governing the Solution of a Modern Steam Engine. It contains much data that will interest engineers and prospective purchasers.

HOMESTEAD VALVE MANUFACTURING COMPANY, Homestead, Pa., has issued a new 1912 catalog and price list illustrating a complete line of valves and specialties.

INSTRUCTION BULLETIN for 2F Type Oil Filtration and Circulating System has recently been issued by S. F. Bowser & Co., Inc., Fort Wayne, Ind. The 2F type is a straight gravity feed system from the gravity tank to the journals, and a gravity drip return from the journals down through the oil clarifying devices to the storage or drip tank in which the several filter sections are placed.

FROM THE MILLER IMPROVED GAS ENGINE CO. comes a new catalog descriptive of its line of high-efficiency gas engines in sizes from 50 to 400 hp., for power plant equipment.

I. H. C. GASOLINE ENGINES is the title of a book recently issued by the International Harvester Company of America. It describes their line of engines in sizes of 1 to 5 hp. for operation with gas, gasoline, naptha, kerosene, ditillate or alcohol.

THE STERLING ELECTRICAL MFG. CO., Warren, Ohio, have issued 60 page book entitled "From Post-hole to 'Lights on' " which describes the new Mazda Street Light system. The poles, or metal ornamental standards, the globes, the conduits, and transformers as well as other material necessary to equip the installation of the new Mazda Street Lighting System are not manufactured or sold by the Sterling Electrical Manufacturing Co., but the list contained and data pertaining to it, are manufactured and sold by the various companies, whose firm name appears in their respective list of material and are merely quoted for the convenience of the customer, as well as to furnish such information as is desired by the different municipalities, business men's clubs and boards of trade of the different cities who have asked for this information.

FROM THE GOULDS MANUFACTURING COMPANY, Seneca Falls, N. Y., we have received a complete set of its late bulletins Nos. 100 to 110 inclusive, bound in attractive pasteboard covers arranged for ready reference. The bulletins are profusely illustrated and describe the product of the Goulds Company.

Another interesting booklet issued by this company is entitled "How and Where Pumping Costs Can Be Reduced" and contains much valuable information for the engineer and intending purchaser.

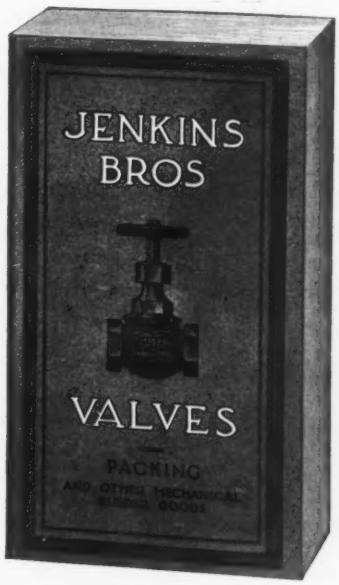
"THERE'S A CHANCE FOR YOU YET" is the title of an attractive booklet issued by the Jefferson Union Company, Lexington, Mass. It gives valuable information on the subject of pipe troubles and their elimination and illustrates the various processess in the manufacture of this company's product. Accompanying this booklet is Catalog A illustrating Jefferson unions, flanges and pipe fitting specialties.

IN A BOOKLET entitled "The Thorough Cleaning of a Smutty Subject," the features of the Claflin steam tube cleaner are explained and illustrated. Copies of the booklet may be obtained from the C. A. Claflin Co., Boston, Mass.

THE CORD AGE is an interesting little publication gotten out by the American Mfg. Co., of 65 Wall St., New York, which can be secured by your name on a postal card. It tells about methods of transmitting power by rope and interesting side issues in connection with various transmission systems.

DESIGN AND CONSTRUCTION of pumps for steam turbine drive is the subject of the latest bulletin No. 1 issued by McEwen Bros., Wellsville, N. Y.

JENKINS BROS., 80 WHITE Street, New York City, and with branches in Boston, Philadelphia and Chicago, have just issued a 1912 catalog and price list. It is a book of 255 pages and aside from listing the standard line of Jenkins valves, packing and other



specialties, contains descriptions of many new devices and much valuable information for the engineering profession. A copy will be sent to interested persons upon request.

DEPARTMENT OF THE INTERIOR Bureau of Mines has issued the following new publications: Bulletin 10. Use of permissible explosives, by Clarence Hall and J. J. Rutledge. Bulletin 23. Steaming tests of coal and related investigations, September 1, 1904, to December 31, 1908, by L. P. Breckinridge, Henry Kreisinger, and W. T. Ray. Technical Paper 8. Methods of analyzing coal and coke, by F. M. Stanton and A. C. Fieldner. Technical Paper 10. Liquified products from natural gas; their properties and uses, by I. C. Allen and G. A. Burrell. Technical Paper 11. The use of birds and mice for detecting carbon monoxide after mine explosions and fires, by G. A. Burrell. Reprint of Bulletin 34. Tests of run-of-mine and briquetted coal in a locomotive boiler, by W. T. Ray and Henry Kreisinger. 32 pp. Reprint of United States Geological Survey Bulletin 412. Copies will not be sent to persons who have received Bulletin 412. The Bureau of Mines has copies of these publications for free distribution, but can not give more than one copy of the same bulletin to one person. Requests for all papers can not be granted without satisfactory reason. In asking for publications order them by number and title. Applications should be addressed to the Director of the Bureau of Mines, Washington, D. C.

DEANE STEAM PUMP CO., 115 Broadway, New York, has issued a new bulletin, D 217, containing descriptions of its Duplex Horizontal Double Acting Power Pumps. The bulletin which is well illustrated with half-tones and line drawings, will be sent to engineers interested on application to the company.

HOW THE ACKERLUND Gas Producer Produces Power and Profit is the title of a book recently issued by the New England Gas Producer Company, Boston, Mass. Interesting statistics and descriptions relating to this company's product are incorporated in the book.

AMONG OTHER INTERESTING matter in the latest issue of the Harvester World, is found the following inspiring poem:

THE SECRET OF THE MACHINES

By Rudyard Kipling

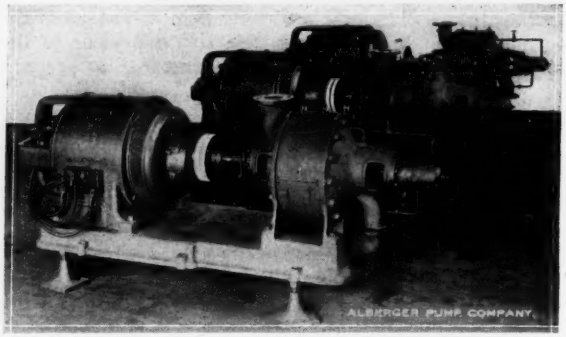
(From "Boys' History of England")

We were taken from the ore-bed and the mine,
We were melted in the furnace and the pit—
We were cast and wrought and hammered to design,
We were cut and filed and tooled and gauged to fit.
Some water, coal, and oil is all we ask,
And a thousandth of an inch to give us play,
And now if you will set us to our task,
We will serve you four and twenty hours a day!
We can pull and haul and push and lift and drive
We can print and plough and weave and heat and light,
We can run and jump and swim and fly and dive,
We can see and hear and count and read and write!
Would you call a friend from half across the world?
If you'll let us have his name and town and state,
You shall see and hear your crackling question hurled
Across the arch of heaven while you wait.
Has he answered? Does he need you at his side?
You can start this very evening if you choose,
And take the Western Ocean in the stride
Of thirty thousand horses and some screws!
Do you wish to make the mountains bare their head
And lay their new-cut forests at your feet?
Do you want to turn a river in its bed,
And plant a barren wilderness with wheat?
Shall we pipe aloft and bring you water down
From the never-failing cisterns of the snows,
To work the mills and tramways in your town,
And irrigate your orchards as it flows?
It is easy! Give us dynamite and drills!
Watch the iron-shouldered rocks lie down and quake
As the thirsty desert-level floods and fills,
And the valley we have dammed becomes a lake!
But remember, please, the law by which you live,
We are not built to comprehend a lie,
We can neither love nor pity nor forgive,
If you make a slip in handling us you die!
We are greater than the Peoples or the Kings—
Be humble, as you crawl beneath our rods!—
Our touch can alter all created things,
We are everything on earth—except The Gods!
Though our smoke may hide the Heavens from your eyes,
It will vanish and the stars will shine again,
Because for all our power and weight and size,
We are nothing more than children of your brain!

TRADE NOTES

SEVERAL NEW TYPES of turbines are being placed on the market by the Terry Steam Turbine Co., of New York, N. Y. One of these, the 3-bearing generator set, is made in sizes up to 25 kw. capacity. Another designed for driving pumps, blowers or generators runs up to sizes of 600 hp. at a speed of 1800 r.p.m. A third type has a vertical shaft and runs in 2 series, the first up to 30 hp., and the second up to 125 hp. This vertical type is especially adapted for driving pumps and centrifugals.

A RECENT ILLUSTRATION received from the Alberger Pump Co., of New York, shows their turbine



pump, which is designed for all pressures from 50 to 500 lb., and is suitable for house, boiler feed, fire and mine service.

DURABLA MFG. CO. since May 1 has occupied the entire 2nd story front of the building where it has been located, at 114 Liberty St., New York City. Its business is increasing rapidly because of the proved quality and reliability of the products, thus necessitating this increase in space occupied. Among these products are the Durabla high-pressure gage glass, a metallic glass of great strength and flexibility which remains clear under practically all circumstances and the sales of which have tripled within the last year. Another product, the Durabla high-pressure asbestos sheet packing, which has been on the market for 5 years, has proved equally efficient for low-pressure and water and for high pressure. A feature is that it can be rolled and unrolled without cracking, due, according to the company's statement, to the special bond which is used for holding the long fiber asbestos in sheet form.

A NEW MATERIAL for insulation against heat, cold and sound, composed of asbestos fiber and hair, made up in layers to give waterproof and fireproof protection, and called "Thermofelt," is described in a recent circular received from the Guyasuta Mfg. Co., Sharpsburg, Pa.

FORM THE CITY OF FALL RIVER, MASS., water works department, E. F. Walker, manager water works dept., International Steam Pump Co., N. Y. City, has received under date of Feb. 7, 1912, the following letter:

Dear Sir:—

Your letter of Jan. 12, and account of duty trials of Providence, R. I., engine received and carefully noted. The reason for not at once acknowledging their receipt was that I was daily expecting from the printers our

Sparks From The Advertising Pages

Send in Those Letters Now!

In the May 1st issue of Practical Engineer we offered 50 prizes for the 50 letters which answered the following four questions with regard to the advertisements in the May 1 and this, May 15, issue in the most comprehensive and logical way:

1st. Which advertisement has, in your opinion, the strongest attention value and why? In other words, which advertisement attracts you most—makes you want to read it?

2nd. Which advertisement is the most interesting?

3rd. Which advertisement is the most convincing—which is the one which makes you feel that what it says is so?

4th. Which advertisements did you answer?

We are doing this because we want to find out just which advertisements appeal to you most.

The advertisers in Practical Engineer are anxious to know just where you think they have struck the right chord. They want to know your opinion of their advertisements and the reasons upon which you have based that opinion.

It isn't our intention to have you write an essay on advertising. As a matter of fact, what we want is something brief and to the point—simply your opinion expressed as simply as you care to word it.

Fifty prizes will be awarded to the engineers who, in our judgment, answer the four questions in the clearest and most logical manner. These prizes are as follows:

(1) For the five best letters: A Richardson direct reading slide-rule for each of the five.

(2) For each of the ten second best: An improved finely tempered Scriber and Tram.

(3) For each of the ten third best: A convenient L. S. Starrett pocket level with strong heavily nickel plated metal case.

(4) For each of the twenty-five fourth best: A copy of "Manual for Engineers," a leather bound pocket hand-book, full of useful information and data for the engineer.

This offer is open to every reader of Practical Engineer with the exception of advertising men, who are barred. We do this because we want the opinions of the men whom the advertisers are trying to reach.

Sit down now with copies of the May 1st and May 15th numbers of Practical Engineer and go through the advertising section, page by page. Pick out the advertisements that you consider best from each standpoint and then in a few words tell us why you think so.

Select the four that you think are best after going through both issues or select four from each—either way will be all right.

All letters must be received by June 1st in order to be considered in the awarding of the prizes, the winners of which will be announced in the June 15th issue of Practical Engineer.

Sit down *now* and start looking through the advertising section. Then write us your opinion. It will be time well spent.

annual report, a copy of which I am forwarding to you by this mail. The high percentage of running time 8599 out of a possible 8760 hr. in the year, or 98.1 per cent, and the yearly duty, "which includes every pound of coal burned at our station," of 90 2/3 million ft. lb., under our erratic pumping conditions (which as you know with no reservoir means anything from an 11 million gal. per hour gait at certain hours of the day to a 3½ million gal. gait at others) must make you feel that the 10-million gal. Worthington pumping engine installed at Fall River is both highly efficient and economical. Under any kind of favorable pumping condition, that is, running at about an 8 to 10-million gal. gait regularly, it would sail close at all times to its guaranteed 135-million ft. lb. duty.

For the year 1910 I returned to the Water Board $2963.07 in coal, that is, I saved that much money in the amount of coal burned as compared to the best previous year in the history of the station. I have for the year just ended, 1911, shown a further saving of $504.70 over 1910, which means that in the two full years ending December 31, 1911, that your Worthington pump has been running, I have saved the City of Fall River, in coal alone, over the best previous year with the old pumps, $6430.84, which means after paying the interest on the original investment, $43,000 that I can establish a sinking fund at 3 per cent, with the remainder and retire the cost of the pump in about 18 years.

Trusting the above facts and figures may be as gratifying to you as they are to me, I remain,

Very truly yours,

John W. Moran, Chief Engineer.

PRACTICAL ENGINEER CLASSIFIED ADVERTISEMENTS

Advertisements in this section are inserted under regular headings at the rates of 30 cents per line. About nine words make a line. No display type allowed, but the first three words may be set in capital letters. Minimum space sold, two lines.

Under classification, "Positions Wanted," advertisements not exceeding four lines will be inserted for subscribers once free of charge.

To insure proper classification, copy must reach this office 10 days preceding publication.

Positions Wanted

POSITION WANTED—As chief engineer, over 12 years experience in all kinds of power plants. Broad technical education. Now in responsible government position at Washington. Desire to change to hotel, office, or similar position. Prefer Central States. Address Box 224 Practical Engineer, Chicago, Ill. 5-15-1

POSITION WANTED— By engineer 29 years old, married. Three and one-half years experience with high speed engines, Westinghouse turbine, A. C. & D. C. generators, water tube boilers, I. C. S. course. Exemplary habits, industrious. Address E. E. Bowman, Morgantown, W. Va. 5-15-1

POSITION WANTED—As engineer by man 30 years of age. Have had 5 years experience with Corliss and High Speed engines, alternating and direct current dynamos, boilers and pumps. Can show first class references. Apply C. J. H., care of Rev. Jos. Sunter, Stonechurch, Le Roy, N. Y. 4-15-1

WANTED—A LIVE UP-TO-THE-MINUTE engineer in a hustling western city would like to secure the agency for a good line of Packings and Steam Specialties. Address with full particulars, Box 222 Practical Engineer, Chicago, Ill. 5-15-1

Help Wanted

WANTED—A MAN WHO understands the setting up and starting of high speed engines, both simple and compound. State experience and wages expected. Address Box 223 Practical Engineer, Chicago, Ill. 5-15-1

AGENTS WANTED—WE WANT a live-wire agent, either engineer or speciality salesman in every town to furnish lists of names and take orders for Akron Metal Gaskets, the most complete line of metal gaskets made. Write for our proposition. Akron Metallic Gasket Company, Dept. PE., Akron, Ohio. tf

HELP WANTED—ENGINEER WANTED in every city and town to instruct our customers in indicator practice. If you have a fair working knowledge, we will "do the rest." Good pay to reliable, intelligent men. Write for particulars. Lippincott Co., Newark, N. J. tf

Wanted

WANTED—EVERY ENGINEER to have our pamphlet for setting valves on Corliss Engines, simple and compound, with one and two eccentrics. Sent free. Lindstrom's Machine Works, 200 South Third St., Allentown, Pa. tf

IF YOU ARE a night engineer, spend a few hours each day taking subscriptions for Practical Engineer. You will be paid well. Write the Subscription Dept. They will start you in at once. tf

For Sale

FOR SALE—INDICATOR, REDUCING WHEEL, planimeter, best make, in fine order. Examination allowed before payment. Price low—in fact, a sacrifice. Address Mrs. N. L. Browning, East Orange, N. J. tf

Patents and Patent Attorneys

PATENTS OF VALUE—Prompt and efficient service. No misleading inducements. Expert in Mechanics, Book of Advice and Patent Office Rules free. Clements & Clements, Patent Attorneys, 727 Colorado Bldg., Washington, D. C. 5-15-6

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. 186 McGill building, Washington, D. C.

VALUABLE INVENTIONS WANTED—Mail description for free opinion of patentability immediately. Patents bought or sold for interested parties. A. P. Connor, E. E. Registered Patent Attorney, Washington, D. C. 5-1-2

PATENTABLE IDEAS WANTED—Send for 3 free books. R. B. Owen, 28 Owen Bldg., Washington, D. C. tf

Educational and Instruction

FREE TUITION BY MAIL—Civil service, drawing, engineering, electric wiring, agricultural, poultry, real estate, automobile, law, normal, academic, bookkeeping, shorthand courses. Matriculation, $5. Write for our free plan. Apply to CARNEGIE COLLEGE, Rogers, Ohio. 5-15-6

Miscellaneous

EVERY ENGINEER should be posted regarding the new system of vacuum heating installed without payment of royalty; I have valuable information; write today. M. Y. C., 1413 W. Jackson Blvd., Chicago, Ill. tf

FORMULAS AND RECIPES for everything, 25c each. Address E. B. Stauffer, Ephrata, Pa. 5-15-1

MAKE MONEY on the side. Here's your chance to pick out some money for yourself. Get subscriptions for Practical Engineer. It pays well. Just drop a line to the Subscription Dept. They will tell you how. tf

MACHINE DESIGNING IDEAS developed, blue printing at reasonable rates. Address E. B. Stauffer, Ephrata, Pa. 5-15-1